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The Institute of Vitreous Enamellers
The National Ironfounding Employers' Federation
The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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The Adventure of Learning

This week will see the commencement of another session of activity in the many Technical Institutes throughout the country. In London the Sir John Cass Institute is opening a new wing containing extensive metallurgical laboratories, Chelsea Polytechnic is offering improved facilities for instruction in engineering-metallurgy, and the numerous other centres are all doing their best to make provision for the educational needs of industrial students. In the provinces the most outstanding event is, of course, the inauguration of the Foundry Degree Course at the University of Sheffield, but apart from this major event all the usual opportunities for technical training are once more available, in some cases with marked improvements since last session. On the whole it cannot be denied that everything immediately practicable is being done by the joint efforts of educational authorities and professional bodies, such as the Institute of British Foundrymen, to provide adequate means for obtaining technical education; new and improved courses have been arranged and examinations inaugurated to form suitable objectives for students taking these courses. There is, in fact, a distinct boom in technical education as far as the organisation of classes is concerned, but while it is one thing to set up and operate the machinery for technical instruction, the manner in which students avail themselves of this machinery is quite another matter.

It cannot be too strongly emphasised that mere participation in class and laboratory work and success in examinations are by no means a sufficient contribution towards the building up of a full mental equipment. The vital principle in technical as in any other type of education is that the student shall bring to bear on his subject an intense interest—a burning desire for illumination. Study of any kind calls for continuous solo effort; only the student himself, by his own intellectual curiosity and motive power, can absorb and illuminate his subject so that it leads to those automatic recalling, thinking and acting processes which constitute intimate knowledge. Formal instruction provides the background of ideas, but it is the individual imaginative consideration of the principles involved in a particular subject that is vitally necessary for the development of judgment and breadth of view.

A line is sometimes drawn by unthinking academicians between technical and cultural pursuits, as if anything connected with engineering or metallurgy, for example, is of necessity a hum-drum, bread-and-butter topic, of no further intellectual interest or value. In point of fact nothing could be further from the truth. As a character in one of D. H. Lawrence's novels, turning from literary philanderings to the study of the technology of coal as a result of his inherited interests in the mining industry, was led to conclude: "it was far more interesting than art, than literature, poor emotional half-witted stuff, was this technical science of industry." True self-education, whether in Roman history or in foundry practice, frees the learner from prejudices, cramped thoughts and habits, and by developing a fresh and virile attitude of mind leads to a fuller expression of his personality in the environment he has chosen. The Sheffield University project presents an opportunity for the recognition of this intellectual and cultural value of technical science as far as the foundry industry is concerned; it is to be hoped that the humbler students of a Technical Institute will not fail to recognise the same qualities in his work and thus to enrich both himself and his fellows by his fuller and more enthusiastic appreciation of his subject.

Manual Skill and Intelligence.—I

The knowledge of young people passing through the educational system is usually tested by examinations, and there have been in recent years many complaints about the examination system. To begin with, there is a feeling that a system that tests knowledge only is not sound, and that what should be tested is intelligence, the capacity to acquire knowledge and to apply it. In the ordinary examination system a candidate who has a comparatively mediocre intelligence, but who has been systematically crammed by one who knows the examiners and the subject may make a better show than a candidate of higher intelligence, possibly badly taught, or without access to the same degree of cramming. We do not underrate the value of knowledge itself or of the necessity that a certificate should imply a certain standard of knowledge. But business men know that what is learned in the schools can seldom be applied directly to industry, and that it requires intelligence, adaptability and something beyond mere knowledge itself to do well in industry. Speaking generally, psychologists to-day are agreed that what may be called mental skill is a manifestation of general intelligence, and that a man who does well in one thing does

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so because of his general intelligence and that he would do other things equally well too. This is recognised in the industrial world, where promotion to a higher sphere of labour is almost always based on the ability to do well in a lower sphere, often entirely different. Our immediate purpose, however, is not to consider mental skill, so much as manual skill, although we have to note in passing that there is no such thing as mental skill entirely divorced from manual skill. Even a mathematician needs to use a slide rule. Equally there is no such thing as manual skill divorced from mental skill. The simplest manual occupations need a directing brain. Some occupations, such as those of a surgeon or a musician, need a very high degree of both. But we propose in a later issue to consider to what extent manual skill such as has to be exercised by a moulder, a pattern-maker or coremaker, needs a high degree of intelligence. Many industrialists have thought that a high degree of craft skill does not demand a high order of intelligence in the ordinary sense. Can we have one without the other?

Correspondence

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

Routine Analysis of High Sulphur in Steels

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—In your issue of August 2, 1934, you published an article on "The Routine Analysis of High Sulphur in Steels," by Mr. L. D. Hewitt.

I would wish to suggest a few modifications to the method of analysis recommended.

It is much better to use a litre flask and hot acid for the evolution. It is also necessary to standardise the iodine and thiosulphate solutions against a similar high-sulphur steel of similar heat-treatment history. In this case the empirical and somewhat unreliable factors suggested by Mr. Hewitt are unnecessary.

The most important comment which I have to make is that excess standard iodine solution should be added to the alkaline cadmium sulphide before acidifying. If this be not done even with low-sulphur steels and cast irons loss of H_2S occurs. The excess iodine is then back-titrated with standard thiosulphate.

The most important points in this method are: (1) The use of a known similar standard steel; (2) an absolute repetition of evolution conditions, and (3) the addition of excess iodine before acidifying the distillate.—Yours, etc.,

R. C. TUCKER, M.A.,
NEWTON, CHAMBERS & COMPANY, LIMITED.

Thorncliffe, near Sheffield.
September 12, 1934.

THE ANNUAL DISTRIBUTION of prizes, diplomas and certificates to students of Paisley Technical College took place last week. Mr. Hugh Hodgart, managing director of Messrs. Fullerton, Hodgart & Barclay, Limited, Vulcan Iron Works, Paisley, and a governor of the College, presided. Miss M. G. Cowan, O.B.E., M.A., who made the presentations, in the course of an address, said that since the war the Universities and Technical Colleges had come more closely into relation with commerce and industry, and technical education had been developed. She did not think that a degree in science was needed to everyone; some could work best with their hands. Students should be carefully advised as to whether it was really worth while trying for a degree. She made an appeal for greater facilities to allow technical students to study during the daytime. There were 16 centres for technical education in Scotland, with over 20,000 students, of whom only some 9,000 could obtain part-time day instruction. There would be great possibilities for young people who could have the opportunity of studying at day classes.

District Presidents.—No. 4

LANCASHIRE BRANCH OF THE INSTITUTE OF BRITISH FOUNDRYMEN

Mr. W. Norman Cook, B.Sc. (Tech.), President of the Lancashire Branch, is a son of the late Mr. William H. Cook, at one time a prominent member of the Institute. Mr. Cook was educated at Manchester Grammar School and the Faculty of Technology at Manchester

MR. W. NORMAN COOK.

University. Throughout the Great War he served in the Royal Engineers. Mr. Cook is now a director of Messrs. Eagle Brass Foundry Company, Limited, Messrs. Aluminium (Hooley Bros.), Limited, and Messrs. Taylor, Lang & Company, Limited.

Catalogue Received

Core Drying. An advance copy of a new catalogue received from the Foundry & Engineering Company (West Bromwich), Limited, Sandwell Road, West Bromwich, is devoted to dispersing the idea that the Acme continuous stove is only for installation in the largest quantity-production factories. The arguments enunciated in this 12-page pamphlet are that the stove is still efficient when operating at a 50 per cent. load and that cores weighing from ¾ oz. to ¾ cwt. can successfully be dried side by side on the same tray. The stove is now one of three compartments, the first being occupied with preheating, the second with final drying and the third with cooling off. From personal observation we can endorse the claims made for the cleanliness and comfort of these stoves in relation to shop-working conditions. The catalogue is well laid out, but better use could have been made of the typesetter's art. It is available to our readers on application.

Fluorspar and Basic Slag Viscosity

From experimental work on the effect of calcium fluoride on the viscosity of basic slags, free from Fe and Mn, at 1,350 to 1,650 deg., L. SCHWERIN, in "Metals and Alloys," concludes that for any given slag the effect of a given fluoride addition in lowering the viscosity is the greater the lower the temperature, and that at a specific temperature the fluoride effect is a direct function of the amount added. This effect lasts up to 2 hrs. as long as no change occurs in the slag composition.

Random Shots

This "best book" stuff is getting complicated. Book clubs and newspapers vie with one another in announcing the best book of the month, of the year, of the century. The unfortunate thing is that each choose a different book. The discerning book reader concludes that all except one must be wrong, and so he disregards them all. In fact, what he really needs to know is what not to read. This, then, is my idea: let the book clubs and newspapers tell us the *worst* book of the month, and we, avoiding it, will find out the best for ourselves.

* * *

At Christmas time most of us have various awkward relations for whom it is difficult to find presents. Books are notoriously dangerous for rich aunts and country cousins. The uncultured nephew who sent a copy of "Ulysses" (he thought it was a travel book) to his rich uncle, the Bishop of Battersea, deserved all that he got. The unread youth who presented a copy of "Eric, or Little by Little" to his aunt, writer of those very advanced modern novels, made a grave mistake. The crux of the matter is: we want someone to tell us the Most Ordinary Book of the Month, the book that will offend nobody. We want a book that the Bishop will think rather daring but harmless, and the aunt will consider rather dull but readable.

* * *

The idea should, I think, be extended to technical literature. In the tumultuous sea of abstruse theory and tortuous research, who can say that any one book is the best scientific work of the year? Only after many years can the reader get the correct perspective on scientific work. On the other hand, it is comparatively easy to decide that any particular book is "sheer tripe." It would be possible to choose the ten worst scientific books of the year, but very difficult to select the ten best.

* * *

To assist the hard-worked engineer or scientist a special book club might bring out a carefully-classified list of scientific work, something like the following:—(1) A.1. (2) Good research, but indifferent presentation of facts. (3) Brilliant writing, but faulty ground work. (4) Good (or bad) work, indexing good (or bad). (5) Good (or bad) work, illustrations and printing good (or bad). (6) C.3. Then the reader would know just where he was, or was not.

* * *

From the "Morning Post":—

THOUGHTS ON A BANANA.

A Japanese boy, who was learning English, was told to write a short thesis on the banana. A reader sends me the result, which may be new to most of my readers:

"The banana are great remarkable fruit. He are constructed in the same architectural style as sausage, difference being skin of sausage are habitually consumed, while it is not advisable to eat wrapping of banana.

"The banana are held aloft while consuming; sausage are usually left in reclining position. Sausage depend for creation on human being or stuffing machine, while banana are Pristine Product of honourable mother nature. In case of sausage, both conclusions are attached to other sausage; banana on other hands are attached on one end to stem and opposite termination entirely loose. Finally, banana are strictly of vegetable kingdom while affiliation of sausage often undecided."

"MARKSMAN."

IT IS REPORTED that the Metropolitan-Vickers Electrical Company, Limited, of Manchester, have secured an order for a new turbine for the Belfast Corporation's harbour power station.

Future Problems in Ferrous Metallurgy

THE SODA ASH PROCESS

By Colin Duncombe Abell

According to Colbeck and Evans,* and Evans,† the molten iron is treated, preferably in a ladle, with 1 per cent. of its weight of commercial soda ash (about 98.5 per cent. pure), viz.:—20-25 lbs. of soda ash per ton of metal, the molten metal being teemed on to the soda ash which is put into the ladle before pouring. The pouring of the metal on to the ash produces a pronounced reaction, which results in the formation of a multitude of thin streams and globules of slag (afterwards outlined further), which effectively cleanse the metal during their passage upwards to the surface.

According to the first-mentioned Paper, the main reaction which takes place is as follows,

$$Na_2CO_3 + (FeS/MnS) \rightarrow Na_2S + CO_2 + (Fe/Mn)$$

but Colbeck and Evans failed to account for the oxygen obviously set free by this equation or to mention where it had disappeared to, and simply stated that several side or subsidiary reactions took place.

In dealing with molten cast iron and its amelioration one must also remember that a certain amount of oxides is present, more or less balanced by a proportion of silica, these oxides and silica being produced partly in the melting process used and also by the rapid surface oxidation of the molten metal whilst in the ladle or receiver. The amount of oxidation is in proportion to the temperature and increases with it. The conditions may be very accurately described by this series of equations:—

(*a*) $Fe + O \rightarrow FeO$,
(*b*) $Mn + O \rightarrow MnO$,
(*c*) $Fe + CO \leftarrow C + FeO$,
(*d*) $Mn + CO \leftarrow C + MnO$,

and

(*e*) $(Fe, Mn)O + SiO_2 \rightarrow (Fe,Mn)O \cdot SiO_2$, grunerite-rhodonite silicate slag, containing dissolved ferroso-ferric oxide, Fe_3O_4.

The reactions (*a*) and (*b*) are controlled by the back-reactions (*c*) and (*d*), and since the back-reactions are slightly slower than the forward reactions below 1,500 deg. C., there is a surplus of oxide formed which dissolves in the iron and also to some extent forms ferroso-ferric oxide, Fe_3O_4, which is eliminated in the slag. It will be seen below in treating of the soda-ash process *that a small amount of dissolved oxide plus carbon is necessary to the successful operation of the process.*

Actually, the reaction given above by Colbeck and Evans is a subsidiary reaction and the sodium sulphide, if formed, can only exist for a very short period of time due to the fact that molten cast-iron contains oxide inclusions as ferrous oxide, FeO, and to a certain extent ferroso-ferric oxide, Fe_3O_4, together with from 1.5-3.0 per cent. of entangled slag.

The true course of the reactions of the process is as follows, viz.:—

$$Na_2CO_3 + (Fe,Mn)S \rightarrow Na_2S + (Fe,Mn)O + CO_2 \quad (1)$$

$$CO_2 + (Fe,Mn) \rightarrow CO + (Fe,Mn)O, \quad (2)$$

$$Na_2S + CO + 4(Fe,Mn)O \rightarrow Na_2CO_3 + SO_2 + 4(Fe,Mn) \quad (3)$$

$$Na_2CO_3 + M.xSiO_2 \rightarrow Na_2O.M.xSiO_2 + CO_2 \quad (4)$$

The reactions are simultaneous. *The third reaction is very greatly extended by the presence of carbon.* Thus, one sees that carbon monoxide and sulphur dioxide are evolved, not carbon dioxide alone, which cannot exist in presence of molten iron, except over ferrous oxide with carbon monoxide. Sodium carbonate alone is stable up to 1,450-1,500 deg. C., without any very great amount of dissociation and therefore the slag may contain free alkali in the ladle method. The sodium sulphide can only exist momentarily. In the last equation above M represents the bases lime, CaO, magnesia, MgO, and alumina, Al_2O_3, present in the slag entangled with the iron due to the relatively high viscosity of ordinary cupola slags, and also that due to erosion of the daub of the ladle.

The general equation giving the results of this process is as follows, viz.:—

$$Na_2CO_3 + (Fe,Mn)S + 2(Fe,Mn)O + M,xSiO_2 \rightarrow Na_2O.M.xSiO_2 + SO_2 + CO_2 + 3(Fe,Mn) \quad (5)$$

(sulphides) (oxides and slag inclusions) (thin soda slag)

Possibly some amount of grünerite, $FeO.Si_2$, is formed or a silicate of the type $FeNaSiO_4$ or $2FeO.Na_2O.2SiO_2$, (crocidolite), which have lower melting points and also a lower viscosity than ordinary ferrous silicates. The oxidation of the metal to ferrous oxide to an extent dependent upon the amount of soda ash used is almost unavoidable when using the carbonate and causes a loss of from 15-20 per cent. in the silicon content in forming silicates. The process is one which resolves itself into a study of the best means of obtaining the greatest depreciation of the sulphur with the least possible effect upon the other constituents of the iron and *in this respect the addition of ground charcoal is imperative.*

The reactions taking place in the metal during the ascent of the slag to the surface are endothermic but at the same time are slightly exothermic at the surface due to as yet to the unknown extent of the reaction $CO+O \rightarrow CO_2$, at the surface of the molten metal. But the main result being endothermic obviously only very hot metal should be employed and in as large a quantity as possible. One sees from a survey of the effects of the fifth reaction how very effectively this process conduces to the production of a cleaner metal due to the absence of oxides in the treated metal and not actually to the removal of gases alone which are not very greatly soluble in molten iron.

A Modification Recommended

After a small lapse of time, usually 5-10 minutes according to the amount of metal treated, the slag collects on the surface of the iron and is thickened with additions of about one-half or an equal amount of ground limestone, $CaCO_3$, and raked off with a small rabbling tool similar to that used by puddlers. The soda ash combines with the small amounts of silicates and free silica present and the other inclusions giving a low-melting point slag of the high-alkali, low-silica, low-alumina type. The thin soda slag described by Colbeck and Evans contains sodium metasilicate, $Na_2O.SiO_2$ (m-pt., 1,020 deg. C., approx.), and according to Wallace* (*vide* Fig. 1), in the system Na_2O-Al_2O_3-SiO_2, under which this type of slag comes, the effect of additions of limestone is to increase very considerably the melting point of the slag (hence the thickening up). His curve shows a maximum temperature at 58.5 per cent., of α-calcium meta-silicate, $CaO.SiO_2$, corresponding to $2Na_2O.SiO_2,3CaO.SiO_2$, and a minimum at 20 per cent., of α-calcium meta-silicate, not corresponding to any definite formula. The result of making additions of limestone, apart from a small reaction ($CaCO_3 \rightarrow CaO + CO_2$) at 980 deg. C., and also $CaO + SO_2 + 2(Fe,Mn) + CO \rightarrow CaS + CO_2 + 2(Fe,Mn)O$, is shown in tabular form as follows (Table I), viz.:—

TABLE I (*vide* Fig. 1).—*The Effect of Additions of Limestone to the Thin Soda Slag described by Colbeck & Evans.*

$CaO \cdot SiO_2$: α-calcium meta-silicate. Percentage.	$Na_2O \cdot SiO_2$: sodium meta-silicate. Percentage.	Temp., deg. C.	Na_2O. Percentage amounts.	CaO. Percentage amounts.	SiO_2. Percentage amounts.
—	100	1,020	50.80	—	49.20
10	90	970	45.72	4.83	49.45
20	80	915	40.64	9.66	49.70
30	70	1,035	35.56	14.49	49.95
40	60	1,110	30.48	19.32	50.20
50	50	1,160	25.40	24.15	50.45
60	40	1,180	20.32	28.98	50.70

and these correspond to the following proportions of soda-ash ground limestone and sand, viz.:—

TABLE II.—*Nearest Weights of Soda Ash, Limestone, and Sand necessary to Form the Mixtures described above in Table I.*

Soda ash .. lbs.	94	84	75	66	56	47	38
Limestone .. ,,	—	9	17	26	34	43	52
Sand .. .. ,,	49	50	50	50	50	50	50
Temperature (approximate) deg. C.	1,020	970	915	1,035	1,110	1,160	1,180

Highly Aluminous Refractories

It should be noticed here that wherever the alkali comes in contact with the lining of daub of the ladle or the bricks of the cupola the easily-fusible high-alkali, low-silica, low-alumina system obtains locally and hence for this purpose the refractories should be highly aluminous; the most resistant lining other than graphite being a laterite or ferruginous bauxite mixed with a small proportion of clay.

It is obvious, too, that the most important factors in this process are (1) the presence of a high-carbon in the metal in a finely-divided form (if one accepts the germ theory), and (2) the presence of slag inclusions, together with some ferrous and ferroso-ferric oxide. In this respect much more effective refining could probably be obtained by making additions of finely-ground coke or charcoal to the soda ash up to not more than 10 per cent. of its weight and so creating the best conditions for the reactions mentioned above and which are dependent upon the presence of a certain amount of carbon. If available, powdered charcoal is better than coke as it is less resistant to oxidation to carbon monoxide and it also introduces much less sulphur and ash which, naturally, will slightly increase that already to be fluxed.

From this, one comes to the conclusion that a mixture of sodium meta-silicate and calcium

* FOUNDRY TRADE JOURNAL, April 30, 1931, page 305.
† *Ibid*, December 1, 1932, page 331.

* Trans. Ceram. Soc., vol. 9; p. 175; 1909-10.

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meta-silicate, corresponding to the minimum point (about 900-915 deg. C.), and containing 20 per cent. of calcium meta-silicate; both in the finely-ground form, together with 10 per cent. of their weight of finely-ground charcoal, would give the same and possibly even better results in view of the reactions quoted above.

Colbeck and Evans state that additions of sand instead of limestone to cause thickening up of the slag has caused in several cases a decrease in the effectiveness of the process and this is obvious since it retards and practically prevents the third reaction taking place and also tends to combine readily with the ferrous oxide to give a very viscous slag.

Cupolas and the Soda-Ash Process

Here one is faced with slightly different conditions, the lack of appreciation of which tends to obscure the reason for the failures sometimes recorded when using briquetted soda ash in the charges instead of limestone as in usual practice. Here the conditions required are, (1) a reasonably low-melting point slag with (2) a low-viscosity, and (3) a low-solution effect upon the monolithic or brick lining. Slags used in this modification of the soda-ash process are classed under the system soda-alumina-silica, viz.:—Na_2O-Al_2O_3-SiO_2. B. A. Rice* gives three low-melting point eutectics as follow, viz.:—

	Na_2O. Per cent.	Al_2O_3. Per cent.	SiO_2. Per cent.	Melt.-pt., deg. C.
1 ..	51.50	—	48.50	830
2 ..	18.40	—	51.60	860
3 ..	17.50	5.40	77.10	800

which demonstrates the existence of two definite areas of great fusibility, viz.:—(1) high-alkali, low-silica, low-alumina; and (2) high-silica, low-alkali, low-alumina. Any increase in the alumina alters and increases these melting points very considerably, the various fields of this system according to Wallace,† being as follow:—

I.—Compounds:—(1) triple oxides — soda leucite, $NaAlSi_2O_6$, — nepheline, $NaAlSiO_4$.
(2) double oxides—sillimanite, andalusite, and kyanite (m.p. about 1,816 deg. C.).
(3) single oxides—corundum (m.p. 2,050 deg. C.), quartz and tridymite (m.p. 1,610 deg. C.).

II.—The following combinations being capable of existence:—

(1) sillimanite-corundum (2) sillimanite-silica (3) corundum-soda	High-temperature areas.
(4) corundum-nepheline	Low-temperature areas.
(5) nepheline-silica-soda silicate	High-alkali, low-silica type.
(6) soda silicate-silica	High-silica, low alkali type.

In using soda ash in the cupola there is thus a choice of two types of slag, as illustrated above; one a high-silica, low-alkali type, and the other a low-silica, high-alkali type. Both are satisfactory as regard free-running temperature and viscosity, but are not equally useful as regards erosion of the lining. If the high-alkali type is used, then a lining composed of clay and laterite is the most suitable, whereas for a high-silica slag a highly siliceous lining would be effective; the latter seems to be preferred at present but will probably give way to the other type in the near future, as experience demands and shows a better appreciation of the high-alkali type of slag. In this latter type of slag a greater range of safe working is available and a higher-temperature slag may be used by increasing slightly (but only slightly) the alumina content by additions of small-lump fused alumina or purple slag as it is called, to the charges. The reason for the smaller decreases in the sulphur content obtained in the cupola at present is due to the use of the low-alkali slag and also because these slags are not very well known to most metallurgists. For the guidance of workers who are interested and who may wish to make experiments, attention must also be drawn to the solidus and liquidus curves of the system albite,*

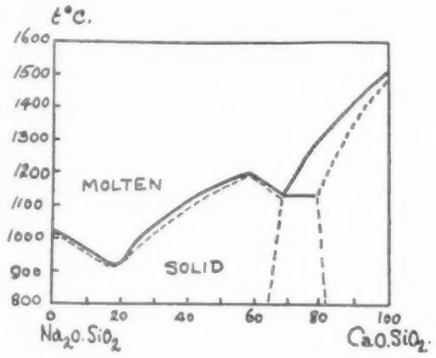


FIG. 1.

$Na_2O.Al_2O_3.6SiO_2$, anorthite, $CaO.Al_2O_3.2SiO_2$, which shows that quite slight increases in the alumina only are necessary when working with these slags, such increases markedly raising the free-running temperatures and increasing the softening range of the slags, the viscosity also being much higher and thus reducing the effective separation of the iron from the slag and aggravating the evil which it is attempted to remove and alleviate (*vide* Fig. 2).

In the cupola process, if soda ash is adopted, slightly more coke should be allowed, and the cupola should run more slowly in order to keep the carbon-monoxide content of the inner zones of the hearth as high as possible, though with certain compositions of the slag slight overrunning is not detrimental.

Treating Steel by the Soda-Ash Process

Colbeck and Evans have not reported any progress in the application of this process to liquid steel, and the writer cannot find anywhere any references to its extended use, even experimentally, and this is rather to be expected in view of what has been said above of the reactions

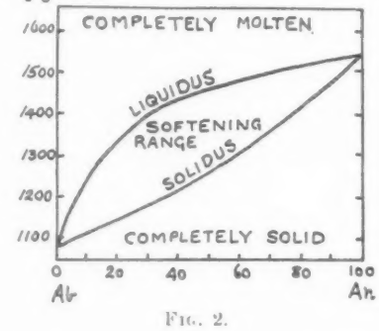


FIG. 2.

which take place, but it can be assumed that the violence of the reaction is too dangerous. Steel, no matter by what process it has been manufactured and before alloy additions have been made, contains very small amounts of carbon and silicon, and the slag inclusions are not of the same character as in molten cast iron. The slag inclusions being mainly silicates, and not oxides, which are apparently necessary to the successful application of this process. Most probably quite successful results, especially as regards degasification of the metal, would be obtained with the mixture of sodium meta-silicate and calcium meta-silicate mentioned above, and if the metal be over-blown, plus a small amount of ground charcoal. The slag can then be thickened up with ground limestone, or better still, with some fused alumina, amounting to about one-quarter of its weight.

An interesting application of this method, working in the cupola, is that known as the Corsalli process, where the product is really a crude steel of much greater strength than cast iron or of white-heart malleable iron. Here one finds that a great many expedients serve the same purpose to varying extents, though a high-alkali slag or "coating," or alternatively a gehlenite slag or "coating," are the most important methods.

Conclusions

(1) Degasification of the metal which is really the elimination of the oxide inclusions, such as FeO and Fe_3O_4, and removal of the sulphur to the extent of some 50 per cent. of that originally present, and, of course, that picked up in the cupola. The metal should be as hot as possible.

(2) That in using soda ash, at least 10 per cent. of its weight of finely-ground charcoal would be an advantage. (Corresponds to 0.10 per cent. carbon in the metal.)

(3) That, better still, a finely-ground mixture of 80 per cent. sodium meta-silicate, $Na_2O.SiO_2$, and 20 per cent. calcium meta-silicate, $CaO.SiO_2$, plus 10 per cent. of its weight of ground charcoal. Thicken up with one-half to three-quarters of its weight of ground limestone (or with ground fused alumina).

(4) That when the ladle method is adopted it counteracts any over-oxidation of the metal due to over-blowing the cupola. Superheating may be used with comparative safety for this reason.

(5) That in using this method in the cupola no more than an equal weight of lime to soda ash should be used, otherwise the results are negative.

(6) For cupola work a slag corresponding to one of the following should be used, preferably the first with a lining as shown in (7) below:—

Na_2O. Per cent.	Al_2O_3. Per cent.	SiO_2. Per cent.
51.50	—	48.50
17.50	5.40	77.10

(7) That the best daub for ladles should not be siliceous, but should be composed of about five parts ground laterite to one part clay, applied in the usual way; similarly, for cupola working, the rammed monolithic composed of the same proportions is suitable for the first type of slag in (6), but a highly-siliceous monolithe must be used for the high-silica, low-alkali type of slag.

(8) Metallographically, the refining effect upon the graphite by the soda-ash process is due to a partial solution of carbon as manganese carbide in place of manganous sulphide, and partly to a slight loss in carbon when operated without the addition of finely-ground charcoal. The use of charcoal also obviates to a large extent the rather large metallic losses associated with this process as at present generally used.

(9) Possibly as the use of the high-alkali type of slag extends and becomes more fully understood a great advance will be possible in the control of the total-carbon content of cast irons, in place of the very ineffective work of to-day.

(10) Probably most future requirements for castings will be filled by the application of the Corsalli process, in conjunction with this modified soda-ash process outlined briefly above.

(11) That the high losses of silicon of from 10 to 20 per cent. will ultimately be overcome by using silicate mixtures as shown above where the necessary silica is already available. The extended use of the modified form of the process will possibly remove most of the prejudice against the use of soda ash, though not in its present state, and will confer a very useful benefit on the foundry industry as a whole.

* J. Amer. Ceram. Soc., vol. 6; p. 525; 1923.
† Trans. Ceram. Soc., vol. 9; p. 175; 1909-10.
* Bowen. Amer. J. Sci., vol. xxv; p. 583; 1913.

Camber on Long Single Casting

This article, which Mr. J. H. Eastham wrote for the "Iron Age," relates to American practice, and as British irons behave differently from American, the actual figures given must be regarded as pointers only.

Machine-tool makers and founders whose lines include numbers of very long castings, such as lathe or planer beds, builders' and ornamental ironwork, are familiar with the tendency to distortion shown while contraction is in progress, and, in the light of much experience, are able to take reasonably accurate steps to counteract it.

For example, a cotton-mill building of saw-toothed roof design may require, say, 100 cast-iron rain-gutter castings approximately 20 ft. long each. The same formula, varying slightly, according to thickness of section and depth of the side walls, is observed on most orders received for castings of this type. A straight skeleton master pattern, with double contraction allowance, is first made. One casting is moulded of skeleton design, each end of the pattern being forced down about 1½ in. during the "bedding-in" process, and the effect observed after removing the cold casting from the mould.

If the camber allowance has been properly estimated, the skeleton casting is finished up and used as a pattern on the rest of the order. This obviously implies that an increased depth of concavity must be allowed in the first place, in order to obtain the correct result on the second casting, and, provided the analysis of the metal used is kept uniform, the rest of the order is plain sailing.

Moulding Channel Design Machine Frame

In the small jobbing foundry, however, equipped with one crane of small capacity, and possessing no very large boxes, the receipt of an order for a single casting of unusual dimensions is an event calling for a carefully-considered plan of action, and, if the contract is to come out on the right side of the ledger, no slips are permissible. A light oblong machine frame of channel design, 16 ft. long, 4 ft. wide, 8 in. deep, and weighing 14 cwts., was ordered from a shop of the type just mentioned, with a request for delivery in four days.

The actual weight of the casting was of minor importance, as it was possible to pour and handle a piece up to about 2 tons, provided its area was not too extensive, thus making the box equipment unwieldy. No box, however, more than half the size necessary to cover the job was available, and it would have cost almost as much money to make one as was received for the single casting ordered. And, above all, there loomed the prospect of a crooked casting being produced if ordinary methods were followed; that is to say, if the metal were poured into a straight mould made from the straight pattern the customer provided.

As the upper face of the pattern was flat with the exception of seven pads, each 1 in. high, placed one on each corner, and the three others spread over the central cross-member, the "cover-core" system of moulding was decided on as being possible, and the necessity for a box of any kind was thus eliminated. For an overall length of 16 ft., and a metal thickness throughout the body of the casting of ⅞ in., a camber allowance of ¾ in. from the centre to each end was assumed to be about right.

With an eye to pouring facilities and gate location, a hole 19 ft. long, 6 ft. wide and 18 in. deep was opened up in the floor under the radius of the small jib crane. A few binder plates were set crossways and surmounted by pieces of rails laid longitudinally to minimise the weight necessary to hold down the body and cover cores when pouring. A layer of floor sand was next spread over the binders and trodden to mould hardness, its upper face being approximately 12 in. below the level of the foundry floor.

Four straight edges, each 4 in. deep, were next levelled transversely in the pit, the distance between the two outer strips being 18 ft., and the space between the two inner ones 2 ft., or, more clearly, each outer strip was placed 9 ft. from a line drawn across the centre of the proposed mould, and each inner strip 1 ft. from the centre. After these were all levelled to each other, and rammed up firmly to their upper edges to avoid displacement, a strip of wood ¾ in. thick was screwed to the upper edge of each of the two inner pieces only, ramming being then continued until the whole area between the four straight edges was filled.

During this operation facing sand was worked into the area to be covered by the pattern, the face of the bed being afterwards struck off in three sections; first, from one outer strip to the nearest inner strip; second, from that inner strip to the other one 2 ft. away; and, third, from the second inner strip to the remaining outer one.

This preliminary preparation provided a convex bed, level for 2 ft. in the centre, with a downward slope to each end strip of ¾ in., on which, when the straight edges had been withdrawn, and the gaps they left tucked full of sand, the pattern was laid, as shown in broken plan and section in Fig. 1. The lightly-constructed hollow pattern sagged naturally to the contour of the bed without any compulsion, and the precautions just taken eliminated all danger of a "twisted" casting, owing to the mathematical accuracy of the advance preparation, which, as the ultimate result showed, was fully justified.

The inlet-gate cores indicated in both views at Fig. 1 were next set to place, a straight flow for the metal along the side walls of the mould to the centre being furnished from a crane ladle at one end, and at the opposite end a 200-lb. shank ladle on each corner. Fig. 2 shows the handy design of gate cores employed on many castings where inlet at the bottom of the mould is desirable, a flat cake core being pasted to a three-sided core, the oblong opening in which may be made of any required size by changing the strip in the bottom of the corebox.

In this connection a strong oil-sand mixture is advisable, as the cores thus made easily stand the pressure exerted when ramming round them, and, in the event of their remaining in the mould a few days before the job is cast, do not readily strike damp.

The square gate sticks, as shown in Fig. 1, were next set vertically in line with the slot in

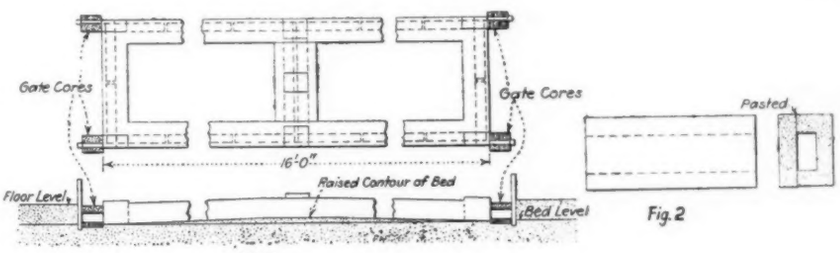


Fig. 1

Fig. 2

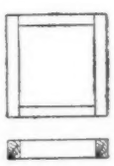


Fig 3

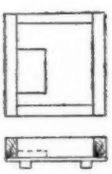


Fig. 4

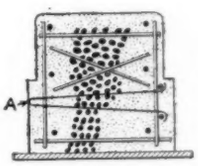


Fig. 5

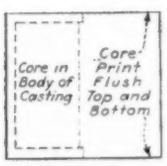


Fig. 6

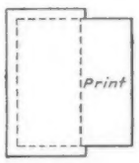


Fig. 7

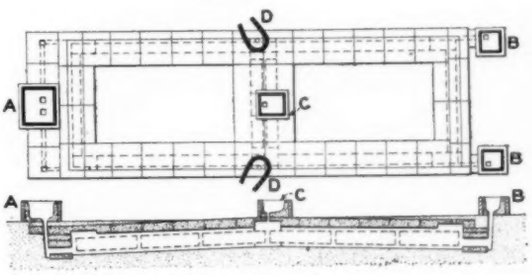


Fig. 8

FIG. 1.—Machine frame pattern in plan and section laid on convex bed to provide necessary camber.
FIG. 2.—Gate cores may be made of various sizes by altering piece in corebox which forms slot, or, by pasting two dished-out units together, capacity may be doubled.
FIG. 3.—Plain open frame used to make 30 slab cover cores.
FIG. 4.—Core frame fitted with bottom board and thickness piece to form pads.
FIG. 5.—Body core on plate immediately after withdrawal of box; *A* is the lifting loop.
FIG. 6.—Pattern as made saved much time in foundry, and eliminated need for chaplets.
FIG. 7.—Pattern as it might have been wrongly made, using standard type projecting core-prints.
FIG. 8.—Plan and sectional views of closed mould. *A*, *A* are main gates; *B*, *B* bull ladle inlets; *C*, *C* auxiliary runner on cross-member; *D*, *D* overflow risers at highest point.

XUM

each inlet core, a rectangular connection being thus formed at each point. A few light weights placed on the pattern to prevent its displacement, and the mould was rammed up to the floor level. The joint was struck off all over flush with the upper face of the frame, slicked, and, after the edges were swabbed, the pattern was drawn out, the mould being then finished and plumbago-coated in accordance with standard practice.

On this—the first day—all the internal cores forming the body of the casting, as well as those to be used as covers in place of a cope flask, were made, a sharp river sand and manufactured core oil mixture being used for both. A smaller oil to sand ratio was used in the cover core mix than in that for the body cores, to ensure greater strength and avoid risk of breaking the cover cores when binding the mould down. A liberal iron reinforcement was also considered advisable for the same reason.

The open frame box used when making the 30 plain flat cover cores is shown at Fig. 3. The same frame, with an added bottom board and an adjustable thickness piece, was employed to form the pads, being indicated at Fig. 4. Ten cores of this type were used, the thickness piece being moved to accommodate right- or left-hand cores as required.

As to the internal or body cores, no special comment is necessary. A substantial coke vent was placed in each, very largely to assist easy contraction, while a single lifting loop of hairpin type, as seen at Fig. 5, facilitated matters when placing the core in the mould.

Attention is here drawn, however, to the patternmaker's foresight in laying out the job with the coreprints flush with the top and bottom of the pattern. A plain square mould is thus formed, saving much time in the foundry; also, as the bulk of each core's total weight was thrown into the print allowance, no chaplets were necessary. The sectional view of the pattern given in Fig. 6 demonstrates this important factor, while Fig. 7, showing the pattern with coreprint as it would have left the average patternshop, gives an idea of the increased cover core and chaplet cost if the pattern had been made that way.

Coring, closing, binding and pouring the metal on the second day presented no unusual features, except that after the body cores were placed, the cover cores were set to correct position by measurement, those forming the pads on the centre cross member being placed first, those necessary to form the corner pads next, and the intervening space filled in last with the plain flat cores made for the purpose. A little filing to ensure a neat fit was, of course, necessary at some of the joints, while others, showing a slack fit, were stuffed with clean cotton waste to prevent sand working down into the mould.

Views of the closed mould in plan and section at Fig. 8 give the gate and riser arrangements; A, A show the main gates to accommodate the crane ladle, B, B those on the corners to receive the metal from the bull ladles, and C, C the auxiliary "pop" gate placed on the centre cross rib, also fed from a smaller ladle to flood the highest area of the casting, with a view to preventing coldshuts. D, D are overflow risers placed on the machining pads to lessen the static pressure set up at the moment the mould is full of metal.

The question of baring strategic points to hasten cooling of the heaviest sections was disposed of by taking the cover cores off the cross rib in the centre, thus exposing the three centre pads. A little sand was also dug from under the casting along each side wall in that area, the rest of the job being left covered and weighted until cold. The sand around the end sprues was, incidentally, slackened to permit easy contraction.

When checked up, cold, on the third morning, the casting was ¼ in. crooked on its length of 16 ft., the ends having risen 1 in. instead of the ¾ in. estimated. This condition was remedied in the usual way, the casting being propped up evenly at each end, weighted in the centre, down to two other props placed under the cross member, brought to a cherry-red heat and allowed to become cold again before the weights were removed. The natural tendency of the piece to spring back to its original shape was counteracted by forcing the centre down a little lower than the ends. The accurate six-point touch formed by the six measured props prevented any chance of further distortion during the straightening operation just described.

A slightly increased manganese percentage in the regular semi-steel mixture used in the shop, bringing that element up to 0.80 per cent. of the metal as poured, gave the casting additional resiliency, and simplified the straightening process considerably.

Cast Iron Sub-Committee Report

DISCUSSION

The Sub-Committee of the Institute of British Foundrymen on Cast Iron has now had an opportunity of considering the discussion on its report and replies as follows:—

The appreciative way in which this Report has been received is greatly valued by the Sub-Committee and is an incentive to it to proceed with its work. The Convener's reply to the discussion is endorsed, but this requires amplification and to be extended to cover the written discussion.

With regard to the effect of total carbon and phosphorus on porosity and the physical properties of cast iron, the Sub-Committee is pleased to note that its conclusions are endorsed by several of the speakers, but would emphasise its opinion that, for the average founder, the obtaining of soundness by a reduction of phosphorus to below 0.3 per cent. is simpler than by a reduction of carbon below 3.0 per cent. The point raised by Messrs. Pearce and Cook with regard to the eutectic has been very closely watched and all the evidence obtained in the experimental work pointed to the existence of some factor around 0.3 per cent. P, which is distinct from the normal effect of variations in the carbon eutectic point. As pointed out by Messrs. Cook and Tucker, this may be due to the form of the phosphide eutectic, but after discussion the Sub-Committee decided that in the present state of knowledge of this subject it could not offer an opinion on the theoretical aspects. With regard to Mr. Campion's point that the short freezing range of low-carbon irons is the main source of difficulty in handling these materials, the Sub-Committee agree that this is one part of the difficulty, but maintain that the high freezing point is also an essential factor. This is a point that requires further investigation.

The remainder of the discussion largely centred round the B.S.I. Specification and the Sub-Committee notes that the "L" bar is considered unsatisfactory by most of the speakers. There should be no difficulty in arranging for an alternative breaking centre for a longer "L" transverse bar, but as Mr. Shaw pointed out, this would be rather cumbersome. The Sub-Committee feels that with the support received in this discussion it can now go ahead with the preparation of suggestions to lay before the appropriate B.S.I. Committee. The Sub-Committee cannot agree with Mr. Shaw that the "S.M." and "L" bars should never be cast together, as it feels that this is the most effective way of investigating the effect of varying section on the physical properties on any composition of iron that is under investigation. On the question of the use of transverse rupture stress the Sub-Committee is definitely of the opinion that these data are much more valuable than the mere expression of breaking stress on a bar, particularly in view of the variety of test-bars now in use. It also considers that a similar expression for deflection in transverse, which takes into account variations in span and depth of test-piece and reduces them to a common level, should be evolved.

The points raised in connection with carbon pick-up will be borne in mind by the Sub-Committee in its future deliberations on the subject. The Sub-Committee thank Mr. Hudson for the data contained in Table A, which are very interesting from many points of view.

The Report is signed by the Convener, Mr. P. A. Russell, B.Sc.

Steel Castings and the Philadelphia Congress

An especially good programme is scheduled for steelfounders at the Fifth International Foundry Congress and 38th Annual American Foundrymen's Association Convention, to be held in the new Convention Hall in Philadelphia from October 22 to 26. In addition to the general-interest sessions, there will be for the steelfoundryman two technical meetings, a round-table luncheon, and a visit to the plant of the Bethlehem Steel Company under the auspices of the Philadelphia Foundrymen's Association.

Among the highlights on the programme are the Exchange Papers. The Institute of British Foundrymen sends a Paper by one of its most distinguished members, Dr. W. H. Hatfield, of the Brown-Firth Research Laboratory, Sheffield. His discussion of "Steel Castings" presents a clear picture of modern steelfoundry practice in England. Dr. Hatfield emphasises the need for co-operation between the designer and the foundryman, illustrating his point with examples of difficult castings.

The Czecho-Slovakian Exchange Paper is entitled "Some Aspects of the Physical Chemistry of Steel Making." Both of the authors, Dr. E. Valenta and Dr. P. Herasymenko, are with the Research Institute of the Skoda Works, at Pilsen, Czecho-Slovakia. They have done a great deal of work on the equilibrium constants of the reactions taking place during steel melting. From their investigations they have developed equations which allow the calculation of the amount of different constituents present, and tables show the close agreement between their calculated and the observed values.

Two other Papers of interest are on the subject of solidification of steel castings. "Controlled Directional Solidification," by George Batty, Steel Castings Development Bureau, Philadelphia, and "Studies on Solidification and Contraction of Steel Castings—II." by C. W. Briggs and R. A. Gezelius, will add to the steelfounder's knowledge of this phenomenon.

The important question of porosity in steel castings, which is receiving so much attention from the industry, will be taken up in detail. An entire session will be devoted to this topic, which will be discussed by nationally-known authorities. Such men as R. A. Bull, consultant on steel castings, Chicago; George Batty, Steel Castings Development Bureau, Philadelphia; C. E. Sims, American Steel Foundries, East Chicago, Ind.; and W. C. Woodward, Geo. H. Smith Steel Castings Company, Milwaukee, Wis., will give the results of their study and experience of this problem. These Papers are essentially practical, treating porosity with the view of determining the cause, and recommending procedure which will provide a remedy for this fault.

At the round-table luncheon meeting there will be two committee reports, one on carbon steel and one on alloyed steel castings, which will undoubtedly provoke a good deal of discussion.

The trip to the plant of the Bethlehem Steel Company, at Bethlehem, Pa., will be made by train, on the afternoon of the last Convention day. Although open to everyone, it should be of particular value to steelfoundrymen.

Developments in German High-Frequency Furnace Design

MAGNETIC FIELD CONTROLLED BY SCREENING

(Specially Contributed)

Modern metallurgy has for some time been demanding a furnace combining the advantages of the arc furnace and its simple form of hearth, with those of the induction furnace and its absolutely pure heat source and thorough mixing of the molten material. Patent literature demonstrates that the creation of a furnace of this kind occupied the minds of inventors decades ago. The demand for an absolutely pure source of heat pointed to the use of induced current. The blending of both requirements, of simple hearth construction and generation of heat by induction, however, was feasible only by renouncing the good conduction of the lines of force obtained with a closed iron core. From this it follows that an induction furnace has a very low power factor. Indeed, power factors of not over 0.08 to 0.1 are attained with such furnaces. These values mean that at least 1,000 k.v.a. are required for creating a heat volume corresponding to an electrical energy of 100 kw.

Experience has shown that the frequencies needed for the operation of these induction furnaces with simple hearth form and without melting trough lie between 300 and 10,000 cycles, the lower values applying to larger, and the higher values to smaller, furnaces. As long as the necessary reactive power had to be generated in a rotary converter, economic operation was not conceivable with such furnaces. When, however, it had become possible to build static condensers dependable enough and low enough in price to dispense with converters, the moment had arrived when the price of a high-frequency furnace plant could be reduced to a point where economical operation became possible, considering the high quality of the material turned out. It is therefore not accidental that the development of the high-frequency furnace set in at the moment when the electrical industry had begun to build dependable high-frequency condensers.

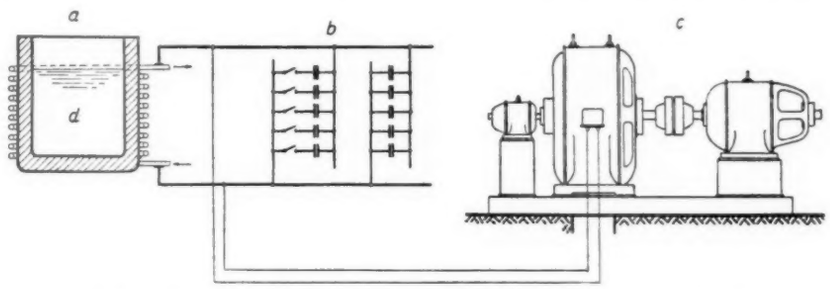


FIG. 1.—SCHEMATIC SECTION OF A HIGH-FREQUENCY FURNACE PLANT.

a, crucible; *b*, condensers; *c*, high-frequency converter; *d*, bath.

The most important components of a high-frequency furnace plant are the furnace proper, the high-frequency generator, and the condensers. Although the switch and wiring installation are also of considerable importance, they are not considered in these notes. Fig. 1 schematically shows the connections of a high-frequency furnace plant. Disregarding small laboratory apparatus, current for the operation of high-frequency furnace is to-day almost exclusively generated by rotary machines. The A.E.G., of Berlin, employs for frequencies under 1,000 cycles the standard models used for generating current of normal frequencies, but for frequencies of from 1,000 cycles up, standard A.E.G. homopolar generators of the type formerly built for wireless purposes are employed. With these converters, frequencies of up to 20,000 cycles are attainable.

The magnetising current required by the furnace coil is supplied by static condensers, in parallel with the high-frequency generator. The condensers are supplied either water-cooled or self-ventilating, the former, however, being most widely used, as they are independent of room temperature. A battery, consisting of 96 boxes each of 204 k.v.a. capacity, is illustrated in Fig. 2. Special safety devices prevent operation of the battery in the event of insufficient cooling-water supply. The danger of water freezing with the battery idle is guarded against by the automatic drainage of the water immediately the supply is cut off.

The furnace itself consists in the main of the coil, the crucible and the frame. The coils principally used are of the water-cooled tubular type, on account of their operating dependability. Experience has shown that the water-cooled coil remains uninjured even in cases of crucible failure, and that operation can be resumed immediately upon repair being effected. The crucible is tamped or fritted with the aid of a template. This method has proved more advantageous, inasmuch as crucibles produced by the fritting method generally are more durable. Cracks in the internal wall do not entail any risk, since the liquid material entering them immediately frits the loose crucible material behind and thereby prevents the escape of metal. Special importance attaches to the design of the furnace frame. As is well known, the supporting structure of the first high-frequency melting furnaces was made of wood, in view of its position in the magnetic field. Since this condition proved untenable in the long run, a change was made to a structural-steel frame, in which the establishment of closed circuits was checked by the interposition of insulators, while the ratio of the coil diameter to the dimensions of the frame structure was made such as to cause the latter to lie in but a weak magnetic field. By the exclusive use of anti-magnetic material for the frame structure, it was possible to reduce the external dimensions of the furnace considerably.

This design was practicable as long as furnaces

FIG. 2.—CONDENSER BATTERY.

FIG. 3.—FURNACE IN POURING POSITION.

of from 1 to 1.5 tons maximum capacity were concerned. When, however, the Friedr. Krupp A.-G., of Essen, ordered from the A.E.G. two high-frequency induction furnaces of a charge capacity of 4 to 8 tons, and at the same time stipulated an extra-rugged design, it became clear that the previously-described carrying structure would not be adequate. It was therefore decided to make use of a patent in the possession of the A.E.G., designing the body of the furnace as a closed vessel and holding the magnetic fields away from the interior vessel structure by screening. A furnace of this design is shown in Fig. 3. It was found that the heat losses in the body of this furnace were extremely low. The two furnaces in question have been continually in operation for a considerable period, and experience has shown that they have fulfilled every expectation entertained with regard to them. These two 4-ton furnaces of the Friedr. Krupp A.-G. are undoubtedly the first in the world of this type. By the results attained with them, they have pointed the way for the design of still larger high-frequency melting furnaces.

All of the difficulties characteristic of the old furnace types have been overcome by this design. In the meantime, units of 30, 400 and 600 kgs. (65, 900 and 1,300 lbs.) charge capacity have been built and put into operation, and these furnaces have shown all of the advantages of the closed-vessel design. With these smaller sizes, another step ahead has been taken, inasmuch as the entire vessel is made from anti-magnetic material, allowing further substantial simplification in design.

Hardness, Strength and Deflection of Cast-Iron Rolls

Chilled rolls must possess a considerable hardness on the surface and a high breaking strength. The latter is exerted by the necks and a layer about 2 to 6 in. thick lying just below the barrel surface. It may seem first as if hardness and strength need not stand in a direct relationship to one another, since the hardness is dependent upon the chemical composition and the chilling action of the mould, whereas the strength is influenced by the quantity and distribution of the graphite and the structure of the metallic groundmass. However, E. Scharffenberg* has found by mechanical tests that these two properties vary in opposite directions. So with chilled rolls an increase in the surface hardness from 419 to 470 Brinell numbers caused the tensile strength of the underlying layer to drop from 14.6 to 7.2 tons per sq. in. The transverse strength fell from 28.6 to 14.9 tons per sq. in. when the hardness increased from 380 to 470. Further tests on bars cut from loam-cast rolls and the neck of chilled rolls showed that a satisfactory relationship between hardness and strength could only be established within the several groups of rolls, viz., chilled rolls, medium-chilled and section rolls, chromium rolls. With increasing hardness the strength increases up to a maximum value and then drops. The following maximum-strength figures were found:—

	Tensile strength. Tons per sq. in.	Transverse strength. Tons per sq. in.	Brinell hardness.
Chilled rolls ..	14.0	27.6	225 to 230
Medium chilled and section rolls ..	17.4	31.8	215 to 225
Chromium rolls ..	15.9	—	195 to 200

The transverse strength being equal, the deflection decreases with increasing hardness.

* "Die Giesserei," 1934, Nos. 27-28.

Heat-Treatment of Cast Iron

The improvement of plain and low-alloy cast iron by quenching and tempering, has been investigated by M. v. Schwarz and A. Väth, and described in "Die Giesserei" (1934, Nos. 33-34). The experiments were made with the following four kinds of iron:—

I. *Alloy cylinder iron.*—T.C., 3.15; Si, 1.9; Mn, 0.62; P, 0.46; S, 0.018; Ni, 1.04, and Cr, 0.35 per cent. Brinell hardness in the as-cast state, 232; tensile strength, 19 to 24 tons per sq. in.

II. *Plain cylinder iron.*—T.C., 3.02; Si, 2.03; Mn, 0.62; P, 0.55, and S, 0.032 per cent. Tensile strength, 15.9 tons per sq. in.

III. *Engineering iron.*—T.C., 2.99; Si, 1.92; Mn, 0.62; P, 0.73, and S, 0.03 per cent. Tensile strength, 12.7 to 14 tons per sq. in.

IV. *High-phosphorus iron.*—T.C., 3.2; Si, 2.45; Mn, 0.7; P, 1.37, and S, 0.105 per cent. Tensile strength, 10.8 to 12.7 tons per sq. in.

Test-bars of 0.788 in. dia. were kept at various temperatures for 4 hrs. and then quenched in oil or water. The hardness was measured about 0.008 in. below the surface, using a 5-mm. ball to which a load of 750 kg. was applied for 30 sec. The hardness values of the oil-quenched bars are given in Table I. When water-quenched the hardness of the four irons remained nearly constant with increasing quenching temperature up to about 500 deg. C., showed a slight increase

TABLE I.—*Brinell Hardness of Oil-Quenched Cast Irons.*

Quenching temp. deg. C.	Iron No.			
	I.	II.	III.	IV.
950 to 960	399	335	348	284
920	—	312	320	274
840	346	283	234	275
760	319	257	165	176
715	210	144	150	164
660	191	144	170	178
600	229	212	215	231
560	235	247	225	228
440	230	235	224	231
350	—	229	—	—

at about 550 deg. C. and then decreased rapidly. At temperatures above 800 deg. C. a sharp rise in hardness occurred. To obtain a Brinell number of 300 in the surface layer the following minimum quenching temperatures must be adhered to:—Material I, 815; II, 830; III, 848, and IV, 865 deg. C. The figures show that phosphorus increases the necessary quenching temperature. By the quenching treatment the density of the irons decreases, the decrease being less than with plain annealing. Hardening cracks were not observable.

After water-quenching from 870 deg. C. the irons were tempered at temperatures between 335 to 700 deg. C. Irons Nos. II, III and IV showed a slight increase in hardness after tempering at 340 deg. C., whereas the hardness of iron No. I remained constant. With further increasing temperature the hardness of all the four irons decreased. The increase in hardness at 340 deg. C. must be attributed to the decomposition of the austenite present in the surface layer, into martensite. With iron No. I the quenching temperature of 870 deg. C. was too low for the formation of austenite, only martensite being present after quenching. An increase in hardness at 340 deg. C. could, therefore, not occur. After tempering at 615 deg. C. this iron showed granular pearlite in the structure, the Brinell hardness being 257. After tempering at 520 deg. C. the high-phosphorus iron exhibited a fine-grained pearlitic structure. The graphite, when present in flakes, does not interfere with the quenching treatment. On the other hand, irons containing eutectic graphite are not suitable for hardening, since the finely-divided graphite decomposes the surrounding austenite into martensite.

A Profitable Week-End

Next week-end—September 29 to 31—The Institute of Vitreous Enamellers is to hold its first Annual Conference. Birmingham has been selected as the venue, because of the concentration of the industry in that centre. It has the full support of the civic authorities, and is being held under the presidency of Dr. J. W. Mellor, F.R.S. On the Friday night there is to be a reception, dinner and dance. The organising committee would welcome the participation of any foundrymen, as they rightly feel that the latter should know as much as possible about the most important finish ever given to cast iron. Vitreous enamelling broadens the field for the exploitation of cast iron. On the Saturday there is a visit to the Parkinson Stove Company, the Presidential Address, and a Paper of general character by Mr. A. England, M.Sc. Anybody interested is cordially invited to participate, and no undue pressure will be exerted to induce them to become members. If any of our readers have not received an invitation, they should write immediately to the honorary conference secretary, Mr. W. Todd, c/o Messrs. Parkinson Stove Company, Limited, Stechford, Birmingham.

Too Many Engineering Students

Discussing the outlook in engineering students, the President of the Educational Science Section of the British Association, Mr. H. T. Tizard, F.R.S., said at the open meeting of the section at Aberdeen on September 6: "Science is a living subject and will assuredly become the basis of all good education as time goes on. I cannot imagine the classics being widely taught in 500 years' time, and I cannot imagine a time when science will not be taught." No scientific man, however, desired to see scientific education pushed to the neglect of literary studies, but they thought that science, well taught, could supply all that is best in the classical tradition. Proceeding to survey the general position in the public schools to-day, Mr. Tizard said: "It is indeed remarkable that through years of industrial depression the public schools have remained full to overflowing; tens of thousands of parents have thought it worth while to sacrifice a large part of their income in order to give their boys the benefit of a public school education. The obvious answer of the public schools to general criticism is that it is not compulsory for anyone to send their boys to them. So long as they perform a useful function they will continue to exist and to be solvent; when they cease to provide a better all-round education than other schools they will die a natural death. In some branches of the engineering industry the University graduate is as welcome as he is in most branches of the chemical industry; but in many he seems to be regarded as a misfit. One prominent manufacturer, who has lived most of his life near a University, has been known to boast that he employs no University graduates. Many employers seem to expect of an engineering graduate a degree of acquaintance with practice that they have no right to expect, for we do not pretend to teach at Universities what can be better learned at the works. Finally, my experience is that too many engineering graduates find themselves in blind alleys from which they have little opportunity to escape." He thought the Universities valued too highly mathematical ability in an engineer, and he was inclined to think there were too many students of engineering at the Universities. Many would be well advised to take advantage of the schemes now in operation for combined training at works and technical schools. The same is true, he suggested, of other branches of technology. The chief aim of a University department of technology should be to produce the leaders of the profession. This they cannot do if they fall into the temptation of mass production.

THE KEEL of the 9,000-ton cruiser obtained by Messrs. Vickers-Armstrong, Limited, under the 1933 Admiralty programme, will be laid shortly at the Walker Naval Yard, which will reopen after two years' idleness.

Physical Properties of Iron-Aluminium Alloys*

By C. Sykes and J. W. Bampfylde

(Abridged.)

An examination of technical literature reveals that a considerable amount of research work has been carried out on this system of alloys. Two Papers, one by Gwyer and Phillips and the other by Körber, give a comprehensive account of the thermal equilibrium diagram of the system. It appears that alloys of iron containing from 0 to 34 per cent. of aluminium consist of a homogeneous solid solution. The system exhibits the phenomena of a closed γ loop, no γ phase being observed after the aluminium content exceeds about 1.2 per cent. The alloys considered here, containing from 0 to 16 per cent. of aluminium with small amounts of carbon and silicon, fall therefore into the above portion of the thermal-equilibrium diagram.

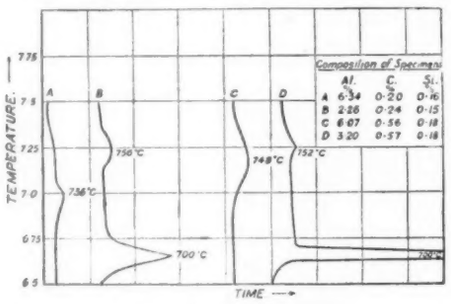


FIG. 1.—COOLING CURVES.

The mechanical properties have been measured several times. Hadfield, in a Paper entitled "Aluminium Steel," described the manufacture of aluminium alloys in a crucible steel furnace. He observed a considerable coruscation due to oxidation, which rendered sand casting difficult. The average carbon content of the steels was about 0.2 per cent. Alloys containing 9 per cent. of aluminium and over would not forge; the tensile strength increased from 29 to 36 tons per sq. in. with an increase in aluminium content from 0.10 to 5.6 per cent. He noted that the alloys do not harden if quenched in water. Osmond, to whom Hadfield submitted a specimen for examination, could find no γ phase, and this Paper probably contains the first reference to this interesting phenomenon. Guillet examined the properties and microstructure of two series of aluminium-iron-carbon alloys—one series with a low carbon content, roughly 0.15 per cent., and the other a higher content of about 0.8 per cent.; the aluminium ranged from 0 to 13 per cent. approximately. He obtained, on the low-carbon series, results essentially similar to those recorded by Hadfield. He recorded that the impact value fell from 26 to 2 kg.-m. in the range from 0.1 to 0.2 per cent. aluminium. Yensen made a study of both the physical and magnetic properties of the alloys. He used a vacuum furnace, of the Arsem type, and took special precautions to avoid contamination by carbon vapours from the heating unit. The furnace was capable of melting 600 grm., and the pressure obtained during melting was less than 1 mm. He segregated the alloys into two groups according to their carbon contents. Alloys containing more than 0.025 per cent. of carbon were more erratic in their physical, as well as magnetic, properties than the alloys lower in carbon. He was able to forge alloys containing up to 13 per cent. of aluminium, although such alloys were quite brittle. During a cursory re-examination of this system it was noticed that certain of the aluminium-iron alloys had particularly good heat-resisting properties, which appeared to merit further investigation. The results of the investigation are recorded in this Paper. The authors then describe the manufacture of the alloys. The following are typical analyses (per cent.):—Swedish iron, carbon 0.05, phosphorus 0.019, sulphur 0.006, silicon trace, manganese 0.06; conductor rail, carbon 0.06, phosphorus 0.010, sulphur 0.024, silicon trace, manganese 0.12. The aluminium contained 0.53 per cent. iron and 0.42 per cent. silicon. The carbon content in the final alloy was about 0.06 per cent. or under.

* Paper presented before the Autumn Meeting of the Iron and Steel Institute.

Discussion of Mechanical Properties

The alloys examined in this investigation appear to be intermediate in properties between those made by Guillet and by Hadfield and those made by Yensen. Alloys completely free from carbon and other impurities should exhibit no marked change in shock resistance with aluminium content. The fact that ductile wire can be produced, and that the ease of manufacture of wire decreases with the aluminium content continuously and not discontinuously, indicates that the material itself is ductile and that intercrystalline fracture in the test-pieces of high-percentage aluminium alloys can be ascribed to films (probably oxide) together with excessive grain-size. For example, alloys in the cast state, even with low aluminium contents, say 3 per cent., are quite brittle.

The behaviour of alloys containing small amounts of carbon is more complex and is best followed by shock tests. Micrographs indicate that the observed properties of this alloy can be explained by assuming a decrease in solubility of carbon with temperature in the iron-aluminium solid solution. This is feasible. Such an explanation is not sufficient for sample B (Al 4.95 per cent., Si 0.103, C 0.05), which, when quenched from temperatures in excess of that corresponding to the usual Ar_3 point, still showed intergranular material.

In order to understand the difference in behaviour of samples A (Al 3.01 per cent., Si 0.155, C 0.06) and B the authors examined various iron-aluminium-carbon alloys containing from 2 to 7 per cent. of aluminium and 0.2 to 0.6 per cent. of carbon. In alloys containing more than 5 per cent. of aluminium the Ar_1 point disappears and the solution of carbon in the aluminiferous ferrite to produce "austenite" takes place comparatively slowly with increasing temperature. Fig. 1 gives four cooling curves which illustrate the effect of aluminium on the Ar_1 point. Such alloys which show an Ar_1 point similar to that in ordinary steel behave similarly, except that the temperature necessary to produce an alloy uniformly martensitic is much higher. Alloys with aluminium in excess of 5 per cent. appear to be quite different in behaviour from steels showing the ordinary transformations on heat-treatment. They have a distinct tendency to deposit intergranular material.

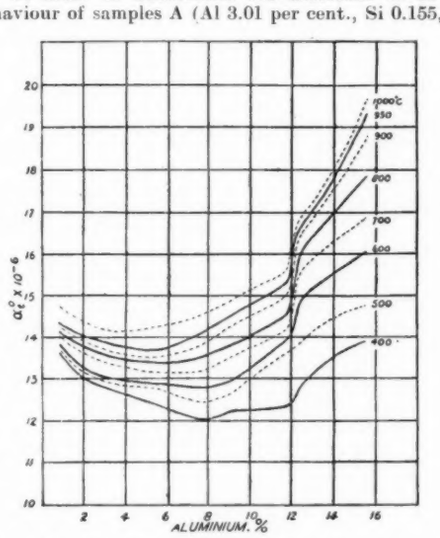


FIG. 2.—MEAN COEFFICIENT OF LINEAR EXPANSION AT VARIOUS TEMPERATURES.

Whilst it is dangerous to extrapolate from alloys containing carbon of the order of 0.6 per cent. to alloys of 0.06 per cent., the authors think that the above experimental data may be used to suggest a tentative explanation of the behaviour of sample B. It is possible that such an alloy will exhibit no Ar_1 point, so that, provided that the intergranular material is formed of deposited carbides, no marked change in solubility (such as takes place in ordinary steel at 690 deg C.) is to be expected at temperatures up to and exceeding 700 deg. C. It is then only necessary to assume that the solubility of carbon in aluminium-iron solid solution decreases as the aluminium content is increased.

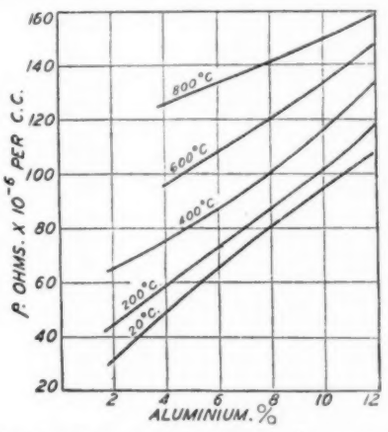


FIG. 3.—RELATIONSHIP BETWEEN RESISTIVITY AND ALUMINIUM CONTENT.

It would appear therefore that ordinary commercial iron-aluminium alloys as cast are brittle (by shock test) due to two causes: (*a*) intercrystalline films of oxide, and (*b*) deposition of carbide in the grain boundaries. Ductility and shock resistance can be controlled in alloys containing less than 5 per cent. of aluminium by heat-treatment; alloys richer in aluminium are more difficult to influence, and under the usual commercial conditions are quite brittle. This short digression on iron-aluminium-carbon alloys has been introduced to show that the difference in behaviour of samples A and B is not fortuitous and that such peculiarities are to be expected. The subject is of great interest and is worthy of further investigation.

Coefficient of Expansion

The expansion of the alloys has been measured from 0 deg. to 1,000 deg. C. for the range 0 to 15 per cent. of aluminium. The results are given in Fig. 2. The curves give the mean coefficient of expansion from 0 deg. C. to the temperature specified. This family of curves exhibits certain peculiarities. There appears (*a*) a change in direction of the curves at 12 per cent. aluminium, and (*b*) a difference in the shape of the curves dealing with the expansion above 500 deg. C. also starting at about 12 per cent. aluminium. The general shape of the curves suggests that some form of transformation occurs in alloys containing an aluminium content greater than 12 per cent. in the range 500 to 600 deg. C. Length-temperature curves taken under conditions of slow cooling show that no discontinuous change in length takes place at any temperature in this range; only the rate of expansion changes.

D

Specific Heat and Density

The specific heat in the temperature range 20 deg. to 100 deg. C. increase from 0.11 for 0.83 per cent. aluminium to 0.13 for a 15.5 per cent. alloy. Aluminium decreases the density of iron when alloyed with it. The actual decrease is less than one would expect simply as a result of admixture, and increases with the aluminium content. The figures given for the specific heat, density and coefficient of expansion may be in error, due to slight variations in the silicon content. The methods used for determining these constants were standard ones, and yielded results which were considerably more accurate and consistent than the actual compositions of the alloys warranted. The trouble could in every case be traced to variations in the silicon content. The authors carried out several experiments in an endeavour to control the silicon content. The alloys absorb silicon from the crucible, if it is present, presumably by reduction. In the ¼-ton furnace the silicon content can be kept below 0.15 per cent., if desired, by using a rammed magnesite lining. However, apart from slight errors due to variation in silicon content, the constants are reliable and can certainly be used,

FIG. 4.—RESISTIVITY AT ROOM TEMPERATURE.

when necessary, in foundry calculations. The density curve may also be used, with reasonable accuracy, for the determination of the aluminium content of the binary alloys.

Thermal Conductivity and Electrical Resistivity

The following results were obtained, using the Forbes' bar method for the determination of the thermal conductivity; the temperature range used was from 40 deg. to 80 deg. C.: Aluminium content (per cent.) and (thermal conductivity), 11.18 (0.050), 12.39 (0.040), 14.36 (0.040), 16.07 (0.024).

These values are very similar to those obtained on steels of the heat-resisting class. The 16 per cent. alloy had very little, if any, temperature coefficient of conductivity.

Fig. 3 shows the variation of the resistivity with temperature for alloys containing from 2 to 11 per cent. of aluminium. The specimens were drawn wires 0.043 in. dia. These were heated in an electric furnace, and the potential drop for a known current was measured over a length of about 4 in. placed in the uniform-temperature zone of the furnace. The potential leads were wires of the same material as the specimen and the connection was made by welding.

In the range from 2 to 11 per cent. aluminium the resistance cold increases uniformly with the aluminium content. The temperature coefficient decreases.

Fig. 4 gives the variation of the resistivity for alloys with from 4 to 16 per cent. of aluminium. The resistivity was measured at room temperature, the specimens being in two conditions: (*a*) as quenched from 700 deg. C. in water; (*b*) after cooling from 700 deg. C. to room temperature at 30 deg. C. per hr.

It will be seen that alloys containing from 12 to 16 per cent. of aluminium are affected by heat-treatment, whereas no effect occurs in those with from 2 to 12 per cent. The effect is a maximum at 14 per cent. aluminium, that is, 25 per cent. by atoms, and is to be associated with a rearrangement of atoms in the solid solution, this arrangement taking place under conditions of slow cooling. From the practical point of view it means that the resistivity of alloys in this range, as measured at room temperature, is dependent on the cooling rate. Above 600 deg. C. the resistivity is, however, independent of the previous thermal history of the material, as the atoms in the solid solution revert to the statistical distribution.

Fig. 5 gives resistivity-temperature curves for a number of alloys, and a gradual change in shape is noticed as the aluminium content is increased. At temperatures above 750 deg. C. the temperature coefficient of the alloys with from 2 to 8 per cent. begins to decrease; for alloys containing 11 per cent. and over the effect is much greater, and the change in resistance with temperature from 600 deg. C. is very small.

The electrical properties of the alloys with from 11 per cent. of aluminium upwards are quite suitable for resistance-element material working in the temperature range from 600 deg. C. upwards.

TABLE I.—*Corrosion Tests on Aluminium-Iron Alloys.*

Aluminium. Per cent.	Salt-spray tests. Relative corrodibility.	Salt-spray tests. Weight Loss. Mg. per sq. cm. per 100 hrs.	Boiler tests. Relative corrodibility.	Boiler tests. Weight loss. Mg. per sq. cm. per 100 hrs.
First test—				
0.83	100	2.7	65	12.0
3.28	53	1.4	100	18.0
5.22	32	0.85	47	8.4
9.02	20	0.54	25	4.4
11.63	19	0.50	37	6.5
12.20	16	0.44	—	—
13.30	7	0.19	29	5.7
15.50	16	0.43	42	7.5
Cast iron ..	94	2.5	—	—
Stainless steel ..	3	0.07	10	1.8
5 per cent. nickel steel	—	—	60	11.0
Second test—				
1.12	100	2.7	65	15.0
3.52	87	2.3	100	25.0
6.03	34	0.90	76	19.0
7.67	30	0.80	24	6.0
9.88	18	0.47	47	12.0
11.81	21	0.55	56	14.0
13.14	18	0.47	45	11.0
14.00	14	0.39	13	3.2
16.16	12	0.31	12	3.1
Stainless steel ..	7	0.18	—	—

Liquid Corrosion Tests

Samples throughout the range were submitted to two tests:—(1) A salt-water spray test, and (2) a boiler test. In the first test the specimens were hung in a tank and sprayed with synthetic sea water. The spraying time was 8 hrs. and an interval of 16 hrs. elapsed before respraying. The total duration of the test was 800 hrs. The specimens were then scrubbed clean and the weight loss determined. The boiler test, which was a short-time test, lasted for a total time of 20 hrs. The boiler contained sea water, and was operated at a steam pressure of 200 lbs. per sq. in. and a temperature of 194 deg. C.

The results of tests on two series of samples are given in Table I.

It appeared from these tests that alloys containing from 10 to 15 per cent. of aluminium were considerably more resistant to liquid corrosion than pure iron, and a further spray test lasting for 1,650 hrs. was carried out in fresh water and sea water with the following results:

	Fresh water. Relative corrodibility.	Fresh water. Weight loss. Mg. per sq. cm. per 100 hrs.	Sea water. Relative corrodibility.	Sea water. Weight loss. Mg. per sq. cm. per 100 hrs.
5 per cent. nickel steel	100.0	0.36	100	1.5
Mild steel ..	68.0	0.25	53	0.8
10 per cent. aluminium alloy..	48.0	0.18	47	0.7
14 per cent. aluminium alloy..	16.5	0.06	33	0.6
Stainless steel ..	8.0	0.03	25	0.3

This test indicated that certain aluminium-iron alloys offer very definite resistance to corrosion.

Resistance to Oxidation

There appears to be no standard test to determine this property of an alloy. One method used consists in placing the specimen in a furnace at the desired temperature for a given time, and then measuring the gain in weight.

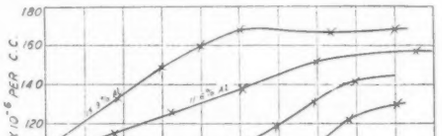


FIG. 5.—RESISTIVITY-TEMPERATURE CURVES.

For aluminium-iron alloys this method is not suitable except in special cases, such as where the temperature is low or when the alloy under consideration corrodes in a similar manner to pure iron. For any given temperature the alloy range may be divided into two groups, in one of which the alloys corrode rapidly and in the other slowly. In the former group the oxide is in the form of a dense scale, which is quite adherent; in the latter, the corrosion product is a very fine powder, varying in colour from red to white with increasing temperature and aluminium content. The powder is so light that it can be removed by drafts, and, indeed, specimens removed from the furnace after 50 hrs. at, say, 1,000 deg. C. often showed a loss in weight even when handled with extreme care before weighing. Determinations of gain in weight on such specimens are valueless. On the other hand, the removal of corrosion products from such alloys is a simple matter, and the resulting loss in weight is a reliable indication of the speed of corrosion. The oxide film which remains on the specimen after cleaning by scrubbing with a wire brush is very thin, and does not affect the speed of corrosion after the first few hours. In regard to the specimens which corrode badly and with an uneven surface, the oxide film remaining on the specimen is, together with corrosion products remaining on the pits, relatively large compared with those obtained from the resistant specimens. As the actual weight of corrosion products is several hundred times larger, this is of no moment. Moreover, the concentration of oxygen in the oxide changes, so that it is possible for one specimen to gain more and yet corrode less than another. Table II illustrates these points (all the specimens had the same shape and size).

As the ultimate criterion of heat resistance is the depth of oxide penetration per unit of time, weight losses in this particular instance seemed to be the quantities to determine. To avoid trouble due to the effect of the polished surface, results have been reported only on specimens previously treated, so that at the commencement of the experiment they carried a scrubbed film similar to the one they might be expected to have when finally weighed. The specimens were cylinders 1.5 in. long and 0.5 in. dia. Two furnaces were used; a nichrome-wound furnace for temperatures of from 900 deg. to 1,100 deg. C., and a molybdenum-wire-wound furnace for temperatures of from 1,100 deg. to 1,300 deg. C. In all the experiments a current of air was passed through the furnace to ensure an adequate supply of oxygen. The furnaces were of the tubular type, arranged to give uniform heating over the zone used, and were automatically controlled by a Cambridge and Paul millivoltmeter at the desired temperature within ± 7 deg. C. The oxidation experiments were continuous, that is, no attempt was made to heat and cool the specimens repeatedly.

TABLE II.—*Oxidation Tests.*

Aluminium. Per cent.	Gain in weight. Grm.	Loss in weight. Grm.
3.01	4.836	17.167
4.95	5.197	13.279
5.84	2.218	6.968
7.33	2.195	5.984
8.75	0.304	0.682
10.30	0.121	0.318
13.07	−0.0474	0.0962
15.02	−0.0182	0.0504

Results.—The results are recorded in Table III, and also in Fig. 6. The figures in the vertical columns 1 to 10 are values of relative corrodibility obtained by dividing the losses in weight of each alloy by the weight lost by the most resistant. Columns 2, 4, 6 and 10 are plotted against the aluminium content in Fig. 6. This method of presentation shows clearly the minimum amount of aluminium necessary to prevent corrosion at the temperatures employed. Although the individual ratios do not agree in the different columns, the line of demarcation is distinct and occurs at the same point.

The alloys oxidising at the very high rates always produce a dense black scale. Alloys in the range of relative corrosion figures of from 10 to 20 are pitted with small holes full of similar scale, the main portion of the specimen being covered with a reddish-white resistant film, whilst the resistant alloys have a perfectly smooth surface covered with a fine powdery oxide film which, when removed, leaves a dull metallic surface.

The oxide film is reddish at all temperatures up to 1,000 deg. C. At 1,100 deg. C., the higher-aluminium alloys—13 to 15 per cent.—give a greenish-white powder, whilst at 1,300 deg. C. alloys which resist oxidation often give a perfectly-white oxide layer. An X-ray photograph of the powder from such an oxide layer showed that, within the limits of the analytical error, the oxide was pure Al_2O_3. In such alloys the penetration of oxygen is particularly uniform, this property being emphasised by tests on fine wires 0.010 in. in dia., the wires being much less prone to hot-spot than the nichrome alloys.

The average losses in weight which occurred in alloys containing from 11 to 15 per cent. of aluminium, determined under the above conditions, were as follow:—

Temperature.	Loss in weight.
1,350 deg. C.	0.022 grm. per sq. cm. per 100 hrs.
1,300 deg. C.	0.016 ,, ,, ,,
1,250 deg. C.	0.0070 ,, ,, ,,
1,200 deg. C.	0.0050 ,, ,, ,,
1,100 deg. C.	0.0020 ,, ,, ,,
1,000 deg. C.	0.0015 ,, ,, ,,

Discussion of Results

That the aluminium content necessary to prevent oxidation increases with the temperature is quite definite. The precise meaning of this is connected with the variation of the concentration of aluminium and iron oxides necessary to produce a resistant film, and has not yet been ascertained. At temperatures in excess of 1,200 deg. C., when the white oxide predominates, this question of relative concentration does not appear to be so important. It is highly probable that any iron atom oxidised is immediately reduced by an aluminium atom. This can occur if the speed of diffusion is in excess of the speed of oxidation. Such a phenomenon would involve a concentration gradient in the alloy, and this, in fact, occurs. A specimen with aluminium 15.06, silicon 0.05 and carbon 0.13 per cent., 8 cm. long and 2 cm. in dia., was heated at 1,350 deg. C. for 50 hrs.; the specimen was then removed, and five layers, 1.5 mm. in radial depth, were turned off and analysed together with the central portion. The results were:—1st layer, 13.73 per cent. Al; 2nd layer, 14.12 per cent. Al; 3rd layer, 14.29 per cent. Al; 4th layer, 14.45 per cent. Al; 5th layer, 14.26 per cent. Al; centre, 14.51 per cent. Al.

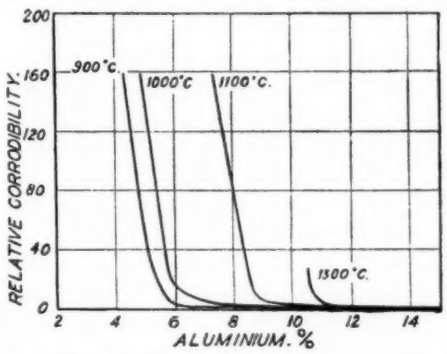


FIG. 6.—RELATIVE CORROSION OF ALUMINIUM-IRON ALLOYS.

Similar results have been obtained on other specimens using ordinary physical measurements. The density varies considerably with the aluminium content, so that this diffusion effect can be followed by measuring the density of the sample as successive layers are turned off. This diffusion is important from the practical point of view, since once the aluminium content gets below a certain value at the surface, the alloy is no longer heat-resisting and collapses.

Another point of interest noted in connection with the diffusion of aluminium is related to the failure of the cylindrical specimens. At high temperatures they almost invariably fail at the edge either at the top or the bottom. Here, there are two adjacent surfaces absorbing aluminium from a comparatively small volume, and consequently that particular portion of the alloy rapidly becomes non-resistant. The scale formed appears to have the property of absorbing aluminium oxide, and consequently the corrosion spreads. For service at temperatures below 1,100 deg. C. there is very little point in using alloys with an aluminium content in excess of 10 per cent., particularly as the ease of manufacture is increased by decreasing the aluminium content. At higher temperatures, however, the maximum aluminium content possible consonant with ability to fabricate, namely, 15 per cent., is desirable in order to allow for considerable life before breakdown occurs, due to diffusion.

TABLE III.—*Analysis and Relative Corrosion.*

Analysis of sample (per cent.)			Relative corrosion.									
Al.	Si.	C.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
3.01	0.16	0.06	133	397	150	241	946	344	—	—	—	—
4.95	0.10	0.05	20	54	122	152	626	257	—	—	—	—
5.84	0.16	0.04	1.3	3.0	36.5	18.4	20.7	140	—	—	—	—
7.33	0.14	0.03	—	—	—	—	—	120	152	—	—	—
8.75	0.13	0.08	1·0	1.5	1.5	3.2	3.2	14.0	8.0	2.1	—	—
10.3	0.23	0.04	1.5	1.0	1.0	1.1	1.4	6.4	2.3	1.0	6.0	21.0
11.16	0.11	0.10	—	—	—	1.1	—	2.2	1.2	—	—	1.4
13.07	0.17	0.06	1.0	1.0	1.4	1.0	1.0	1.8	1.3	1.3	1.0	1.0
15.02	0.13	0.04	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.2	1.0	1.0
Temperature of test, deg. C.			900	900	1,000	1,000	1,100	1,100	1,100	1,200	1,250	1,300
Period of test, hrs.			50	50	50	50	75	50	50	50	25	25

Relationship between Sulphur and Silicon Contents of Cast Iron

By evaluating the analyses of a large number of cast irons melted in six different foundries, F. Roll* has been able to establish a relationship between the sulphur and silicon contents. The irons were not desulphurised and melted in the cupola under similar conditions, using German foundry coke, first-class limestone, and the usual mixtures consisting of pig-iron, steel scrap, runners and risers. The range of analysis was:—T.C., 2.8 to 3.4; Si, 0.6 to 4.3; Mn, 0.5 to 1; S, 0.04 to 0.18, and P, 0.2 to 0.8 per cent. From plotting the sulphur content (ordinate) against the silicon content (abscissa) a group of points results which can be marked off by two straight boundary lines. Within these lines an average curve can be drawn representing the value of probability of the S/Si ratio. The three curves can be expressed by the following equations:—

Top curve—S per cent. = 0.195 − 0.0264 (Si per cent.).
Average curve—S per cent. = 0.162 − 0.0264 (Si per cent.).
Bottom curve—S per cent. = 0.138 − 0.0264 (Si per cent.).

The state of equilibrium represented by the curves must only be taken for a relationship imposed by external factors. By remelting the same iron several times the sulphur content is, therefore, increased, when the silicon content is kept constant. With increasing manganese content the curves are displaced to lower sulphur contents. In the case of hematite pig the following curve was found:—S per cent. = 0.047 − 0.006 (Si per cent.). The S/Si ratio of malleable cast iron containing more than 1 per cent. of silicon is the same as with grey iron, but increases rapidly at silicon contents below 1 per cent.

Alloy Steels for Cracking Plant

Special steels which do not suffer from intercrystalline failure and carbonisation at high temperatures are required for making tubes used in oil-cracking plant, a subject discussed by H. J. SCHIFFLER in "Petroleum." The author points out that the best results are obtained with low-carbon Cr steels containing Mo, Ti, or V, or combinations of these, to prevent changes in the C distribution at high temperature, while the addition of Al improves the resistance to scaling and prevents catalytic action of the steel on the hot oil vapour and consequent deposition of soot in the tubes.

* "Die Giesserei," 1934, Nos. 33-34.

Resistance of Cast Iron to High Temperatures*

INFLUENCE OF SILICON AND ALUMINIUM

By Prof. M. H. Thyssen

(Abridged.)

The process of destruction of ordinary cast iron composed of ferrite and cementite and graphite flakes heated to 900 deg. C. to 1,000 deg. C. is as follows:—

(1) *Externally.*—Attack by gas or by other closely-surrounding matter (for instance, the oxygen, sulphuric anhydride, and the fine particles of silica in suspension present in the hearth gases) and the formation of a film of the products of reaction. This film breaks up, scales off, and by exposing continuously new metal renews the surface open to attack. A true phenomenon of corrosion.

(2) *Internally.*—The gas attack penetrates the graphite flakes in the external film, expels the carbon, then attacks the metal surrounding the flakes; the products of this attack fill the cavity, act as a wedge introduced into the material, and soon fissures appear from the cavity subjected to the attack, thus allowing the atmosphere to reach the flaky graphite at the bottom. The phenomenon repeats itself as the new flakes are exposed right through the test specimen.

This internal corrosion, having the effect of shattering the cavities containing the graphite, has an ultimate result not only in creating fissures in the material, but also in increasing the volume of the test specimen. It is, however, not exclusively responsible. The origin of the action lies in the carbon arising from the decomposition of Fe_3C coming into contact with the graphite flakes; it is generally recognised that this latter phenomenon does not progress like the former from the exterior to the interior, but permeates the whole specimen once heat is applied.

An examination of this process of destruction suggests the following remedies:—(1) Obtain some products of attack forming a continuous adherent film, possessing a coefficient of expansion approaching that of cast iron, and resistant to the diffusion of iron and the elements of cast iron towards the exterior, as well as to corrosion towards the interior. This result can only be obtained by adding to the cast iron certain elements more readily oxidised than iron. (2) Prevent graphitisation by adding elements causing either the formation of heat-resisting carbides or the destruction of all carbide on solidification, leaving in the casting only two stable elements—ferrite and graphite. (3) Reduce or even suppress the anomaly of expansion of cast irons in order to avoid irregular expansion, which induces scaling of the external protective film and internal fissures.

On examining the action of silicon and aluminium employed as added elements to cast iron it is observed:—(1) That these elements are primarily more readily oxidised than iron and, secondly, the products of their reactions with the hearth gases are stable and strongly adherent. (2) That they cause graphitisation on solidification, producing the stable condition of the iron—ferrite-graphite—when they are added in suitable proportions. (3) That they raise the anomaly of expansion of cast iron, proportionately to the quantity dissolved, and that, given correct quantities, they can raise it sufficiently to render it no longer troublesome.

These two metals, therefore, fulfil exactly the conditions enumerated. This discovery decided the author and his colleagues in 1931 to undertake a methodical study of the system iron-silicon-aluminium in relation to resistance to high temperatures. When they undertook their research, they had for reference a large number of works on silicon-iron, of which the two principal ones, sufficiently contradictory in any case, are those of Rugan and Carpenter in 1909, and of Norbury and Morgan in 1931.

According to tests made on casts with about 3.90 to 4 per cent. of total carbon and 1 to 6 per cent. of silicon, Rugan and Carpenter concluded that silicon caused an increase in bulk and in weight. On the contrary, Norbury and Morgan show that suitable proportions of carbon and silicon endow cast iron with excellent properties to resist high temperatures.

The action of aluminium on cast iron had received very little investigation. The only works of that time the authors had found are:—(1) That of Everest, a first memorandum published in August, 1927. He studied the variation of the mechanical properties of cast iron in relation to the aluminium content. In a second memorandum he indicated that such irons would prove very resistant to high temperatures. (2) The work of Norbury and Morgan, who in 1931 made tests on high-silicon, high-aluminium irons. They stated that an iron containing about 5 per cent. of silicon and 8 per cent. of aluminium offers very good resistance at 1,000 deg. C. The author then gives a description of the experiments made at Liége.

The results may be summarised as follow:—

(1) The theoretical deductions which prompted this research are entirely confirmed by experience. It has, in fact, been discovered that the addition either of silicon or of aluminium or of these two elements combined in quantities sufficient to produce irons of ferritic structure and with the transformation point above the temperature to which they may be heated, completely nullifies the two causes of destruction—corrosion and growth—or at least weakens them very considerably.

(2) The results derived are of interest, because if an iron is such that it has a very narrow freezing range, it is by a judicious choice of the contents of silicon, aluminium, carbon and manganese that this result is obtained. It will have been observed in the course of this work that all the interesting irons are found around the eutectic line and in no case were they hypereutectic. This is considered to be very important, but it lies beyond the programme of this research. The author believes, in fact, that for most of the results likely to be aimed at by the foundryman in working his metal, it is necessary to approach as closely as possible to the alloy with the minimum solidification range, while avoiding carefully the hypereutectic zone. By doing so, he obtains, first—as pointed out by M. Portevin—maximum fluidity, and beyond this he suppresses or greatly modifies the more serious foundry defects and produces sound work much more easily. The necessity of keeping in the neighbourhood of the minimum solidification interval need not alarm the foundryman. The determination of fluidity provides an easy and certain way of verifying if the alloy responds well to this exigency.

(3) In this research the transformation point has been raised and stable equilibrium has been attained by three different means:—(i) By the addition of silicon, (ii) by the addition of aluminium, and (iii) by the simultaneous addition of silicon and aluminium, to an ordinary foundry iron. It is seen that these three methods provide a means of preventing the destruction of ordinary irons by heat. However, these three means give very different results. The second solution is the least successful, because the mechanical properties of such irons are not acceptable. Both the other solutions have advantages. The first possesses simplicity in application and a reduced cost; the third produces irons with enhanced mechanical properties and resistance to destruction. The addition of aluminium is not popular with foundrymen generally, because it demands considerable experience and often produces much slag with a loss of aluminium; and sometimes it means working very viscous alloys, principally when the melt is not hot enough. It may be said without hesitation, however, that the alloys with narrow solidification ranges which have been made were fluid enough to enable the small test-pieces demanded for the Chèvenard tests to be cast. The aluminium irons, however, have the drawback of very viscous slag if remelted without special precautions.

* Paper read at the Autumn Meeting of the Iron and Steel Institute.

Heat-Resisting Alloys

Mr. Bassal, writing in "Revue de Métallurgie" on the subject of "The Use of Metals in the Construction of Furnaces," has given figures, reproduced in Table I, which show the comparative temperatures where rapid oxidation sets in for a number of metals and alloys.

TABLE I.—*Accelerated Oxidation Temperatures for Various Metals and Alloys.*

Metal or alloy.	Temperature of accelerated oxidation in deg. C.
Ordinary cast iron or that with low Ni or Cu additions	650 to 750
Austenitic cast iron with Ni-Cr-Cu with or without Al- additions	850
Irons with 20 per cent. Cr	900
Ordinary and low-alloy steels	600 to 700
Steels with 13 per cent. Cr	850
Steels with 25 per cent. Cr	1,100
Austenitic steels 18 per cent. Cr; 8 per cent. Ni	1,000
Alloys of Fe-Cr-Al (10 per cent. Al; 3.5 per cent. Cr)	1,000
Alloys of Fe-Al (14 per cent. Al; 74 per cent. Fe*)	1,100
Alloys of Fe-Cr-Si-Al (0.12 per cent. C*; 1.0 per cent. Si; 7.8 per cent. Cr*; 0.6 per cent. Al; 0.3 per cent. Mo*)	1,100
Ferro nickel Ni-Cr (60 per cent. Ni; 15 per cent. Cr; 5 per cent. Fe)	1,100
Ferro nickel Ni-Cr (86 per cent. Ni; 15 per cent. Cr; 5 per cent. Fe)	1,200
Copper	1,000
Nickel	900
Calorised steel (cemented with Al)	900
Steel cemented with Cr, Ti, or Bo	900
Steel cemented with Zi	1,000

* In another formula aluminium is replaced by 0.3 to 0.4 per cent. of vanadium.

A second table gives loads admissible at elevated temperatures for various classes of irons. They are detailed in Table II.

TABLE II.—*Safe Working Load of Cast Iron at Elevated Temperatures.*

Type of iron.	Maximum permissible load in tons per sq. in. at	
	350 deg. C.	450 deg. C.
Ordinary cast iron	1.9	—
High duty cast iron	3.1	2.5
Nickel cast iron	3.8	3.1
Molybdenum cast iron	4.4	3.8

From an American source, Mr. Bassal gives the following compositions for metal containers:—

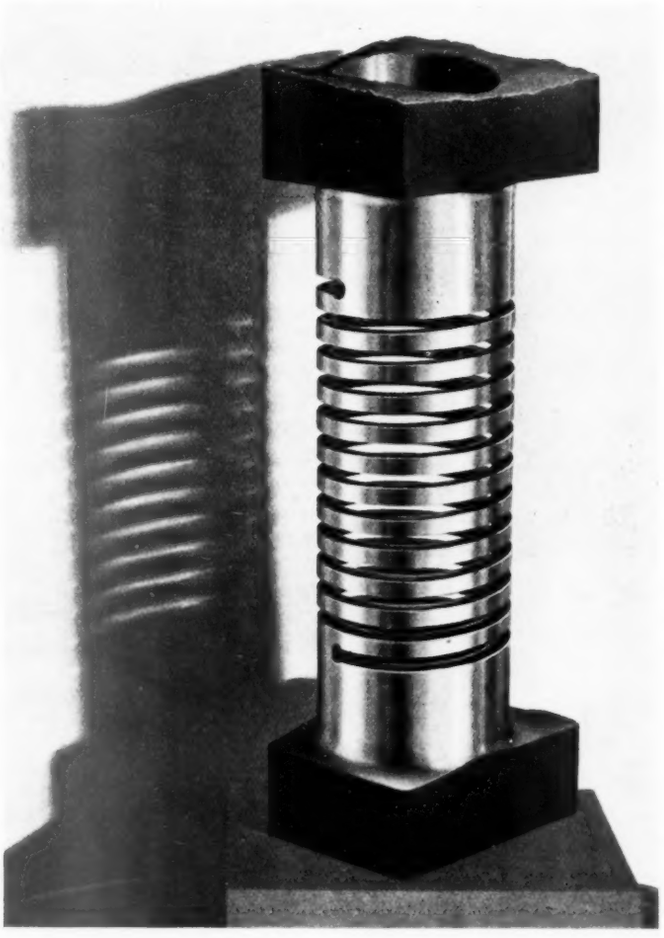
Lead Baths.—T.C., 3.25; Si, 1.90; Mn, 0.60; Cr, 0.51; Ni, 0.69; S, 0.08, and P, 0.32 per cent.

Glass-Bottle Moulds.—T.C., 3.4; Si, 1.00; Mn, 0.50; Cr, 0.3, and Ni, 1.00 per cent.

Aluminium Melting Pots.—T.C., 3.3; Si, 0.95; Mn, 0.60; Cr, 0.20, and Ni, 1.00 per cent.

Not a Shadow of Doubt—

Regarding the
MERITS of "NEW PROCESS" IRON



Users of "New Process" Iron have proved for themselves that the claims made are in no way exaggerated.

The illustration provides an excellent example of the close uniform grain, free from porosity and segregation, and the high physical properties which make such machining possible.

*A Standard Pig of "**New Process**" Iron machined to the shape of a 3-in. diameter spiral spring.*

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Telephone: Gateshead 71181. *Telegraph: "Closework, Gateshead-on-Tyne."*

This Week's News in Brief

Trade Talk

MESSRS. YARROW & COMPANY, LIMITED, Glasgow, are to supply their latest type of side-fired boilers to H.M.S. "Grenville," which they are building for the British Admiralty. This particular type of boiler has been quite recently introduced by Messrs. Yarrow, and has been fitted to the "Conte di Savoia" and the "Strathaird." It is also being fitted in the new Cunarder, No. 534.

FURTHER EVIDENCE of the improvement in the steel trade of Mossend is given by the announcement that another melting furnace will be in operation at Messrs. Stewarts and Lloyds' Clydesdale Steel Works this week. For the employees retained since the transfer of the heavy mill to Corby, work has been plentiful, and present indications are that this state will continue for a larger number of men.

ADDITIONAL FLOOR SPACE is now being laid out at the works of the British National Electrics, Limited, at Newarthill, near Mossend, Lanarkshire, in view of the firm's decision to include vitreous enamelling in their activities. Formerly this work was done outside, and the decision to carry out the process in their own works will result in a considerable number of new employees being taken on.

THE HIGH-SPEED motor vessel, "Sir Hastings Anderson," built by Messrs. Harland & Wolff, Limited, at their Clyde yard for H.M. War Department service, has completed very successful trials on the Clyde. The vessel, which is propelled by eight cylinder airless-injection four-cycle direct reversible trunk Diesel engines of the Harland "B. & W." type direct coupled to the propeller, has been specially designed for towing targets at high speeds.

MESSRS. BALFOUR, BEATTY & COMPANY, LIMITED, contractors for the Scottish Power Company, besides being responsible for the work on the Grampian scheme, and associated with electricity line extensions in Ross-shire, have received an important contract in Baghdad. The contract is for the construction of the Kut Barrage in Iraq for a modified tender of more than £1,000,000. Six tenders for the work were submitted, the highest being from a German firm.

LAST WEEK, Messrs. Shirlaw Allan & Company, of Hamilton, offered for sale the whole of the plant and machinery belonging to Messrs. Matthew Paul & Company, Limited, Levenford Brass Works, Dumbarton (in liquidation). The sale attracted a large number of buyers, and there was brisk competition for many lots. The prices obtained were on the whole satisfactory, especially for the smaller tools and material. The major part of the work previously carried out by Messrs. Paul is now transferred to Messrs. Jas. Howden & Company, Limited, Glasgow.

THE NATIONAL EXECUTIVE of the United Patternmakers' Association has decided to restore the remainder of the cuts imposed on staff employees from October. The decision has been taken following an application by the National Union of Clerks. Branches of the Association have been told that the election of the general president will take place at the quarterly meeting this month. The candidates are: Messrs. Baird, Stockport: Buchanan, Glasgow, and Short, Newcastle East. If a second vote is necessary it will be taken at the meetings in November.

MESSRS. BAIRDS & DALMELLINGTON, LIMITED, have just acquired Mauchline Colliery, which originally belonged to the Caprington & Auchlochan Collieries, Limited, now in liquidation. The area of untapped minerals around Mauchline is one of the largest in Scotland, and with the development expected to be undertaken by the new owners, work is likely to be found for a much larger number of men. The Auchlochan Collieries of the company have been acquired by Messrs. William Dixon, Limited, for a substantial sum. The Bourtreehill Fireclay Works of the company have been carried on successfully by the liquidator during the past year.

IRISH FREE STATE TRADE RETURNS for the month of July show that imports of machinery and electrical goods and apparatus totalled £275,794 for the month, against £115,501 for the same period in 1933, making for the seven months £1,404,529 against £1,043,011. Agricultural machinery made up £6,824; bread machinery, £4,652; boilers and boiler-house plant, £5,778; boot-making machinery, £1,719; dairy, £4,656; electrical, £34,033; grain milling, £2,623; printing, £12,800; and textile, £6,878. During the month £4,629 worth of machinery and tractor parts were exported, valued at £6,200, and re-exports under the same head were valued at £3,104, making for the seven months £38,768.

Personal

LORD HIRST, chairman of the General Electric Company, Limited, who has undergone a serious operation, is stated to be progressing favourably.

SIR H. C. HAROLD CARPENTER, F.R.S., is resigning the honorary treasurership of the Iron and Steel Institute at the end of September. He has held the position since 1926. The Council of the Institute, at the meeting held in Brussels last week, nominated him as President-Elect. Sir Harold Carpenter is Professor of Metallurgy at the Royal School of Mines, Imperial College of Science and Technology.

SIR HAROLD CARPENTER, F.R.S.

Born in 1875, he was educated at St. Paul's School and Merton College, Oxford, afterwards going to the Universities of Leipzig (where he obtained his Ph.D.) and Manchester. He went to the National Physical Laboratory at the time of its foundation as head of the Chemical and Metallurgical Departments. He obtained the Carnegie Gold Medal for research awarded by the Iron and Steel Institute in 1905, and from 1906 to 1913 he was Professor of Metallurgy at the Victoria University, Manchester. Sir Harold Carpenter is a Past-President of the Institute of Metals, and is President of the Institution of Mining and Metallurgy. He is the author of numerous researches on metals and alloys in the "Proceedings" of the Royal Society, the "Journals" of the Iron and Steel Institute, the Institution of Mechanical Engineers, the Institute of Metals, etc.

THE EDUCATION COMMITTEE of the Corporation of Glasgow have appointed Mr. John Longden, foundry superintendent with Messrs. D. & J. Tullis, Limited, Clydebank, principal teacher in moulding and foundry practice at the new Trades School in Glasgow.

ON SATURDAY, SEPTEMBER 15, Mr. W. P. Nairn, accountant to Messrs. William Jacks & Company, won the Essex Amateur Golf Championship at the Thorndon Park Club's course, near Brentwood, with a score of 144 for 36 holes. In his first round Mr. Nairn established a new amateur record for the course.

Will

PAUL, GEORGE BUTCHER, ironfounder, late of 27, Glasgow Road, Denny £954

THE STANTON IRONWORKS COMPANY, LIMITED, have secured a large contract for pipes for Mexico City.

Company Reports

Radiation, Limited.—Interim dividend on the ordinary shares of 3⅛ per cent.

Ferranti, Limited.—Dividend of 6 per cent. on the ordinary shares for the year to June 30.

British Insulated Cables, Limited.—Interim dividend of 5 per cent. on the ordinary shares.

Imperial Chemical Industries, Limited.—Interim dividend of 2½ per cent. on the ordinary shares.

Murex, Limited.—Final ordinary dividend of 20 per cent., less tax, for the year ended June 30 last, making 35 per cent.

Qualcast, Limited.—Final ordinary dividend of 10 per cent., making 15 per cent., less tax, for the year to June 30 last, and a bonus payment of 5 per cent., also less tax.

Contracts Open

London, September 27.—Iron and steel stores, for the G.W.R. Company. The Stores Superintendent, Swindon.

Birkenhead, September 27.—Iron and steel stores, for the Mersey Railway Company. Mr. J. Shaw, general manager and secretary, Central Station, Birkenhead.

Ragnall, etc., September 29.—Providing and laying 17,472 yds. of 3-in., 4-in. and 6-in. water main and incidental works, for the East Retford Rural District Council. Mr. J. Turrill, surveyor, 2, Market Square, Retford, Notts. (Fee £3 3s., returnable.)

Obituary

MR. ANGUS C. MILLAR, works manager, The Fullwood Foundry Company, Limited, Mossend, died at his home at Jerviston, Motherwell, on Sunday last. He was 59 years of age.

MR. LEWIS MACKRELL, formerly well known as the head of James Mackrell & Company, Limited, engineers, of Union Foundry, Elland, died recently. He had been connected with the firm, founded by his father in 1865, all his working life, retiring nine years ago.

THE DEATH OCCURRED very suddenly on September 8 of Mr. Alexander M'Isaac, Scottish divisional store superintendent, L.N.E.R., Cowlairs, Glasgow. Mr. M'Isaac was playing a round of golf at Prestwick when he suddenly collapsed and died immediately.

Iron and Steel Output in August

The British Iron and Steel Federation reports that there were 97 furnaces in blast at the end of August, compared with 99 at the beginning of the month, two furnaces having ceased operations. Production of pig-iron in August amounted to 503,300 tons, compared with 527,200 tons in July last and 362,700 tons in August, 1933. The production includes 134,000 tons of hematite, 240,500 tons of basic, 118,400 tons of foundry and forge pig-iron. The output of steel ingots and castings amounted to 667,000 tons, compared with 718,200 tons in July last and 551,300 tons in August, 1933.

Forthcoming Events

SEPTEMBER 25.

Sheffield Metallurgical Association:—Social Evening. Members only.

SEPTEMBER 27, 28 AND 29.

National Smoke Abatement Society:—Sixth Annual Conference, to be held at Glasgow.

OCTOBER 2.

Sheffield Metallurgical Association:—"Industrial Efficiency," lecture by Sir William Larke, K.B.E., at 8 p.m., at the Mappin Hall, The University, Applied Science Department.

Institute of British Foundrymen

OCTOBER 3.

London Branch:—"The Dagenham Foundry of the Ford Motor Company, Limited," Paper by V. C. Faulkner and J. N. Burns.

OCTOBER 5.

Wales and Monmouth Branch:—Opening Social and Whist Drive at Cardiff.

LIGHTNESS *for* CAR ENGINES

The illustration* shows a Sunbeam "Dawn" engine, well lightened by the use of aluminium alloys for the cylinder block, crankcase, pistons, flywheel and clutch housing, gear-box housing, steering box, induction pipe, valve gear covers and brake shoes.

(*By courtesy of the Sunbeam Motor Co., Ltd.)

Standard forms of B.A. Co. aluminium include Virgin Aluminium (98/99% and higher purities) in 2¾-lb. notched bars; Alloys (ready mixed to B.A. Co., British Standard and special specifications) in 6½-lb. ingots.

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for Motor Cylinders, Valve Bodies, Steam and Hydraulic Castings, Etc.

LONDON OFFICE:
59, VICTORIA ST., S.W.1.

THE BARROW HÆMATITE STEEL CO., LTD., BARROW-IN-FURNESS, LANCS.

Raw Material Markets

Business in the iron and steel markets continues to show a gradual expansion, but the recovery has not yet come up to expectations. The production figures for August reveal a decline in both iron and steel, and, as a result, it has been suggested that the British market has reached saturation point, and that the stimulus given by the import duties has now spent its force. In view of the fact that August was a holiday month, however, this seems to be a somewhat premature judgment.

Pig-Iron

MIDDLESBROUGH.—The market in Cleveland foundry iron maintains its firm tone. With an increased demand from Scotland, and a normal call from other consuming areas, the ironmasters can dispose of the whole of their output as made, and are looking forward to moving the stock that accumulated during August. So far, however, forward buying has been slow, business being chiefly for deliveries over the next few weeks. Export business remains limited and unremunerative. The fixed minimum rates for home deliveries of No. 3 Cleveland G.M.B. remain as follow:—Middlesbrough, 67s. 6d.; North-East Coast, 69s. 6d.; Falkirk, 67s. 3d.; Glasgow, 70s. 3d. per ton. Half-a-crown per ton more than the foregoing figures is quoted for No. 1 foundry iron, and both No. 4 foundry and No. 4 forge are 1s. per ton less than No. 3.

For some time it had been expected that an increase would be made in the price of East Coast hematite, in view of the rising costs of coke and foreign ore. The market was not greatly surprised, therefore, when on Friday last the makers announced an advance of 1s. per ton on the fixed minimum prices to home consumers. It appears that the advance is limited to Middlesbrough and the North-East Coast, and that delivered prices to other destinations remain unaltered. In Middlesbrough the revised quotation is 69s. per ton and to other destinations on the North-East Coast 71s. per ton. These are the first changes since the fixed minimum prices were instituted.

LANCASHIRE.—Increased forward buying of pig-iron is reported from this area, a number of foundries having contracted into the early months of 1935. There is a steady current demand for iron. Values are steady, with offers of Staffordshire, Derbyshire and North-East Coast makes of No. 3 all quoted for delivery to users in the Lancashire area on the basis of 74s. per ton, with Northamptonshire at 72s. 6d. and Derbyshire forge iron at 69s. The demand for Scottish iron locally continues on a restricted scale, but, at about 82s. 6d. per ton, delivered equal to Manchester, there has been no change in the price position. West Coast hematite, at about 80s. 6d., and East Coast at from 75s. to 76s., according to quality, both delivered Lancashire, are steady.

MIDLANDS.—Conditions in this area have shown little change during the week. The light foundries remain busy and their autumn and winter prospects are very satisfactory. A number of the larger iron-founders have bought supplies until the end of March at the current rates. Midland pig-irons, including delivery to Birmingham and Black Country stations, are 67s. 6d. per ton for Northants No. 3 and 71s. per ton for Derbyshire, Lincolnshire and North Staffordshire No. 3, with 5s. less for forge pig-iron. There are indications of expansion in the demand for iron for the general engineering trades. There is a wide range on offer of these particular grades, the prices of which vary to a very considerable extent according to analysis and tonnage. Limited quantities of Scottish and other low-phosphorus irons come into the district regularly at prices between 85s. and 87s. 6d. per ton. Medium-phosphorus pig-iron is quoted between 72s. 6d. and 80s. per ton and refined from £5 10s. to £6 15s.

SCOTLAND.—There has been little change in the demand for Scottish foundry iron, which remains at 70s. f.o.t. furnaces for No. 3, with 2s. 6d. extra for No. 1. The light-castings foundries continue to consume large quantities of English iron, in addition to local iron of a high-phosphorus content. No. 3 Cleveland remains at 67s. 3d. f.o.t. Falkirk and 70s. 3d. f.o.t. Glasgow, other English irons being obtainable at slightly less.

Coke

Conditions in the foundry-coke market are unchanged, prices remaining firm. New business is limited, as so many consumers have already entered into forward contracts. Current quotations for delivery in the Birmingham area are 36s. to 40s. for best Durham coke, 40s. to 41s. for Scottish coke, and from 37s. 6d. to 45s. per ton for Welsh coke, according to analysis and tonnage.

Steel

Business has developed steadily since the beginning of the month, and although there has been no heavy rush of orders, the expansion in nearly all departments has been in accordance with expectations. The demand in all sections of the market is largely upon home account. The export markets buy only spasmodically, and business is handicapped by the exchange restrictions in force in many foreign countries. The situation in the semi-finished steel department is satisfactory, although the demand is not so active as in the early part of the year. Foreign competition in the home market, however, is not serious, and the arrangements between the British consumers and producers provide the latter with a steady flow of work. There has been a fair amount of activity in the finished-steel branches of the industry, and a noticeable increase in the volume of inquiry. The heavy-steel works have a good reserve of work in hand.

Scrap

There is a steady demand for scrap iron in the Cleveland area, heavy cast iron in furnace sizes being at 50s. and good cast-iron machinery scrap at 52s. 6d., with light metal on offer at about 41s. Conditions are unchanged in the Midlands market, prices remaining at the levels which have ruled for a long time. In Scotland, foundries are not offering more than 54s. to 55s. for machinery cast iron in pieces not exceeding 1 cwt., and 51s. 6d. to 52s. 6d. for ordinary cast to the same specification. In South Wales there is a slightly firmer market for heavy cast iron at about 47s. 6d. to 48s. 6d., but good cast-iron machinery scrap, at 52s. 6d., is in very limited demand.

Metals

Copper.—The outlook in the copper market is far from good at the present moment. The quotation for standard metal has receded to about the lowest level seen this year, and shows no sign of making a recovery; indeed, a further fall is looked for in some quarters. The industrial demand for refined metal has been poor, both as regards this country and the Continent. In connection with the latter market, the involved financial situation remains a discouraging feature, but it is hoped that something concrete will result from the visit of the official British mission to Germany. The latter country's imports of non-ferrous metals have been very restricted lately. The copper situation in the United States shows no improvement and it is feared that an attempt may be made to break below the N.R.A. official price of 9 cents per lb. delivered Connecticut Valley.

Daily market prices:—

Cash.—Thursday, £27 7s. 6d. to £27 8s. 9d.; Friday, £27 6s. 3d. to £27 7s. 6d.; Monday, £27 5s. to £27 7s. 6d.; Tuesday, £27 6s. 3d. to £27 7s. 6d.; Wednesday, £27 10s. to £27 11s. 3d.

Three Months.—Thursday, £27 12s. 6d. to £27 13s. 9d.; Friday, £27 11s. 3d. to £27 12s. 6d.; Monday, £27 11s. 3d. to £27 12s. 6d.; Tuesday, £27 12s. 6d. to £27 13s. 9d.; Wednesday, £27 15s. to £27 17s. 6d.

Tin.—The price of tin on the London market has continued to fluctuate, under the influence of speculative buying and selling movements. The outstanding feature of the situation has been the heavy premium which has ruled for "spot" tin, as compared with forward supplies. This tightness of prompt supplies is likely to persist, as a further cut of 10 per cent. in production is due to take place at the beginning of next month; that is to say, unless the "buffer pool" exercises a far stronger influence upon the market than it has done up to the present.

"Trade demand in this country is satisfactorily maintained and a moderate business is reported on the Continent. In the United States of America, however, some irregularity prevails and buying has been of a rather spasmodic description, markets there being still under the influence of the labour troubles and the uncertainties which surround the economic situation generally. The outlook meanwhile is still uncertain, and the establishment of a heavy backwardation, with all that it implies, serves only to confuse the situation rather in creating a sense of artificiality, which has a disturbing effect on sentiment," report Messrs. Rudolf Wolff.

Price fluctuations:—

Cash.—Thursday, £229 17s. 6d. to £230; Friday, £229 5s. to £229 10s.; Monday, £228 10s. to £229; Tuesday, £228 15s. to £229; Wednesday, £228 15s. to £229.

Three Months.—Thursday, £227 5s. to £227 10s.; Friday, £227 2s. 6d. to £227 5s.; Monday, £227 to £227 5s.; Tuesday, £227 to £227 2s. 6d.; Wednesday, £227 2s. 6d. to £227 5s.

Spelter.—Confidence in this market has been badly shaken, and some time will probably elapse before it is recovered. The sudden fall in price, to the lowest level seen for two years, was unexpected, and can only be accounted for by the disturbed situation on the Continent, as there has been quite a fair demand from spelter users in this country. The market was disappointed at the United States spelter statistics for August, which reveal a further increase in stocks of about 4,500 short tons, the total now being over 102,000 tons.

Day-to-day quotations:—

Ordinary.—Thursday, £12 11s. 3d.; Friday, £12 11s. 3d.; Monday, £12 8s. 9d.; Tuesday, £12 5s.; Wednesday, £12 7s. 6d.

Lead.—Consumption of this metal has been very satisfactory as regards this country. The building trade has been very active throughout the summer, lead pipes and sheets have been in good demand, and cablemakers also report that they have been more active lately. The sudden collapse in the price of lead is not therefore due to any failing in this direction, but rather to the troubled financial and industrial situation on the Continent, coupled with an abundance of supplies. Until some measure of industrial recovery is seen in Germany and France, and until the producers take steps to reduce the present high stocks of lead, the value of the metal is likely to remain at its present low level.

Price fluctuations have been as follow:—

Soft Foreign (Prompt).—Thursday, £10 5s.; Friday, £10 5s.; Monday, £10 5s.; Tuesday, £10 5s.; Wednesday, £10 6s. 3d.

SOMMERFIELD'S POLICY IS TO SERVICE AS WELL AS SELL

PIG IRON. We will gladly advise you as to the most economical and satisfactory iron for your particular requirements, and guarantee prompt supply and lowest prices.
FOUNDRY SUPPLIES. We have large London stocks of sands, fuels, refractories and all requisites, and a willing staff to interpret your every need.
SAND BLAST. Our service engineer is at your disposal when in trouble, and we can advise on and supply plants, abrasives, hose, gloves and everything necessary.

REPRESENTING: ST. GEORGE'S ENGINEERS, Ltd. MANCHESTER

H. G. SOMMERFIELD, LTD.
Charterhouse Chambers, Charterhouse Square, E.C.1 Phone: CLERKENWELL 2869

AGENTS FOR COLVILLE'S PIG IRON

Wm. CUMMING & Co. Ltd.

The Leading Manufacturers!
The Oldest Established!!
The Most Reliable!!!

Ironfounders' Facings Manufacturers and General Foundry Furnishers,

Kelvinvale Mills, Maryhill, GLASGOW

Branches at Falkirk, Chesterfield, Deepfields and Middlesbrough

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SUPERFINE COAL DUST

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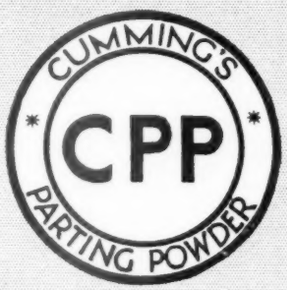
SUPERLATIVELY REGULAR IN GRIST.
SUPERIOR IN QUALITY.
SEVEN GRISTS STANDARDISED.
ONE QUALITY OF COAL THROUGHOUT.



INGOT MOULD BLACKING

THE BEST ON THE MARKET.
MANUFACTURED BY THE NEW PROCESS.

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BRITISH PLUMBAGOS

AT LOW PRICES.
IMPORTED DIRECT.
NO CONTINENTAL ADULTERATION.

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CUMMING FURNACE

USERS OF THE NEW "CUMMING" FURNACE ARE INCREASING WEEK BY WEEK.

CORECOMPOUNDS, PARTINGS, CUMMINGSTONE, REQUISITES, BLACKINGS for every PURPOSE

ALL OUR OWN MAKE

RAW MATERIALS—PRICE LIST

(Wednesday, September 19, 1934)

COPPER

	£	s.	d.
Standard cash	27	10	0
Three months	27	15	0
Electrolytic	30	7	6
Tough	29	7	6
Best selected	29	17	6
Sheets	58	0	0
India	40	7	6
Wire bars	30	15	0
Ingot bars	30	15	0
H.C. wire rods	33	7	6
Off. av. cash, August	28	7	10 1/11
Do., 3 mths., August	28	15	1 3/11
Do., Sttlmnt., August	28	7	10 1/11
Do., Electro, August	31	14	1 7/22
Do., B.S., August	31	9	8 5/11
Do., wire bars, August	31	18	7 7/11
Solid drawn tubes			9½d.
Brazed tubes			9½d.
Wire			6¼d.

BRASS

Solid drawn tubes	8¾d.
Brazed tubes	10¼d.
Rods, drawn	8¼d.
Rods, extd. or rlld.	4¼d.
Sheets to 10 w.g.	7d.
Wire	7¼d.
Rolled metal	6¼d.
Yellow metal rods	4¼d.
Do. 4 × 4 Squares	5¾d.
Do. 4 × 3 Sheets	5¾d.

TIN

	£	s.	d.
Standard cash	228	15	0
Three months	227	2	6
English	228	15	0
Bars	230	12	6
Straits	228	17	6
Australian (nom.)			—
Eastern	229	5	0
Banca	230	0	0
Off. av. cash, August	228	4	1 7/22
Do., 3 mths., August	228	1	5 5/11
Do., Sttlmt., August	228	5	8 5/11

SPELTER

	£	s.	d.
Ordinary	12	7	6
Remelted	13	5	0
Hard	10	5	0
Electro 99.9	15	0	0
English	13	0	0
India	12	5	0
Zinc dust	17	0	0
Zinc ashes	3	0	0
Off. aver., August	13	14	4½
Aver. spot, August	13	13	7 7/11

LEAD

	£	s.	d.
Soft foreign ppt.	10	6	3
Empire (nom.)	11	2	6
English	12	10	0
Off. average, August	10	18	5 1/4
Average spot, August	10	16	5 3/22

ALUMINIUM

Ingots	£100 to £105
Wire	1/1 to 1/9 lb.
Sheet and foil	1/2 to 2/9 lb.

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	23	10	0
Do., V.M. ex-whse.	22	15	0
Rods	27	0	0

ANTIMONY

	£	s.	d.		£	s.	d.
English	43	0	0	to	45	0	0
Chinese, ex-whse.					37	0	0
Crude						—	

QUICKSILVER

	£	s.	d.		£	s.	d.
Quicksilver	11	2	6	to	11	10	0

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	£8 17 6
45/50%	£13 0 0
75%	£18 7 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	5/6 lb. Mo.
Ferro-titanium—	
23/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£14 10 0
Ferro-tungsten—	
80/85%	3/- lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	£29 15 0
4/6% car.	£23 0 0
6/8% car.	£21 12 6
8/10% car.	£21 12 6
Ferro-chrome—	
Max. 2% car.	£36 0 0
Max. 1% car.	£38 15 0
Max. 0.70% car.	£42 0 0
70% carbon-free	10d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	5/3 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to £11 5 0
76/80% packed	£11 15 0 to £12 5 0
76/80% export	(nom.) £9 15 0
Metallic manganese—	
94/96% carbon-free	1/2 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 1/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

South Wales—	£	s.	d.		£	s.	d.
Heavy steel					2	15	0
Bundled shrngs.					2	7	6
Mixed iron and steel	2	10	0	to	2	11	0
Heavy cast iron	2	7	6	to	2	8	6
Good machinery					2	12	6
Cleveland—							
Heavy steel					2	10	0
Steel turnings					1	15	0
Cast-iron borings					1	8	0
Heavy forge					2	10	0
W.I. piling scrap					2	5	0
Cast-iron scrap	2	10	0	to	2	12	6
Midlands—							
Light cast-iron scrap					2	7	6
Heavy wrought iron					2	17	6
Steel turnings, f.o.r.					1	12	6
Scotland—							
Heavy steel	2	10	0	to	2	12	6
Ordinary cast iron					2	12	0
Engineers' turnings					1	19	6
Cast-iron borings					1	19	6
Wrought-iron piling	2	11	3	to	2	12	6
Heavy machinery	2	13	6	to	2	15	0

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	25	0	0
Brass	16	10	0
Lead (less usual draft)	9	10	0
Tea lead	7	0	0
Zinc	9	0	0
New aluminium cuttings	66	0	0
Braziery copper	22	0	0
Gunmetal	22	0	0
Hollow pewter	145	0	0
Shaped black pewter	110	0	0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	70/-
Foundry No. 3	67/6
„ at Falkirk	67/3
„ at Glasgow	70/3
Foundry No. 4	66/6
Forge No. 4	66/6
Hematite No. 1	69/-
Hematite M/Nos.	68/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	72/6
„ d/d Birm.	84/6
Malleable iron d/d Birm.	115/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	67/-
„ No. 3 fdry.	71/-
Northants forge	63/6
„ fdry. No. 3	67/6
„ fdry. No. 1	70/6
Derbyshire forge	67/-
„ fdry. No. 3	71/-
„ fdry. No. 1	74/-
Scotland—	
Foundry No. 1, f.o.t.	72/6
„ No. 3, f.o.t.	70/-
Hem. M/Nos. d d	71/-
Sheffield (d/d district)—	
Derby forge	64/6
„ fdry. No. 3	68/6
Lincs forge	64/6
„ fdry. No. 3	68/6
E.C. hematite	81/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	74/-
Staffs fdry. No. 3	74/-
Northants fdry. No. 3	72/6
Cleveland fdry. No. 3	74/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	82/6
Clyde, No. 3	82/6
Monkland, No. 3	82/6
Summerlee, No. 3	82/6
Eglinton, No. 3	82/6
Gartsherrie, No. 3	82/6
Shotts, No. 3	82/6

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£	s.	d.		£	s.	d.
Bars (cr.)	9	12	6	to	9	15	0
Nut and bolt iron	7	10	0	to	8	0	0
Hoops	10	10	0	and up.			
Marked bars (Staffs) f.o.t.				12	0	0	
Gas strip	10	10	0	and up.			
Bolts and nuts, ¾ in. × 4 in.				14	0	0	
Steel—							
Plates, ship, etc.	8	15	0	to	8	17	6
Boiler plts.	8	0	0	to	8	10	0
Chequer plts.				10	7	6	
Angles				8	7	6	
Tees				9	7	6	
Joists				8	15	0	
Rounds and squares, 3 in. to 5½ in.				9	7	6	
Rounds under 3 in. to ¼ in. (Untested)				8	12	0	
Flats—8 in. wide and over				8	12	6	
„ under 8 in. and over 5 in.				8	17	6	
Rails, heavy	8	5	0	to	8	10	0
Fishplates	12	5	0	to	12	10	0
Hoops (Staffs)				9	7	0	
Black sheets, 24g. (4-t. lots)				10	10	0	
Galv. cor. shts. („)				13	0	0	
Galv. flat shts. („)				13	10	0	
Galv. fencing wire, 8g. plain				14	10	0	
Billets, soft	5	10	0	and up.			
Billets, hard	6	17	6	to	7	2	6
Sheet bars	5	2	6	to	5	10	0
Tin bars	5	2	6	to	5	7	6

PHOSPHOR BRONZE

	Per lb. basis.
Strip	9d.
Sheet to 10 w.g.	10d.
Wire	11½d.
Rods	10d.
Tubes	13d.
Castings	11d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	20.26
No. 2 foundry, Valley	18.50
No. 2 foundry, Birm.	14.50
Basic, Valley	18.00
Bessemer	20.76
Malleable, Valley	18.50
Grey forge, Valley	18.25
Ferro-mang. 80%, seaboard	85.00
O.-h. rails, h'y, at mill	36.37½
Billets	27.00
Sheet bars	28.00
Wire rods	38.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	1.80
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.70
Steel hoops	2.10
Sheets, black, No. 24	2.40
Sheets, galv., No. 24	3.10
Wire nails	2.60
Plain wire	2.30
Barbed wire, galv.	3.00
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	25/- to 30/-
„ furnace	19/- to 20/-
Durham foundry	20/- to 25/-
„ furnace	17/6
Midlands, foundry	—
„ furnace	—

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box		18/2
„	28×20 „		36/4
„	20×10 „		26/- to 26/1½
„	18¾×14 „		18/7½ to 18/9
C.W.	20×14 „		15/7½
„	28×20 „		33/6 to 33/9
„	20×10 „		22/9 to 23/-
„	18¾×14 „		16/-

SWEDISH CHARCOAL IRON & STEEL

	£	s.	d.		£	s.	d.
Pig-iron	£6	0	0	to	£7	0	0
Bars-hammered, basis	£16	0	0	to	£16	10	0
Bars and nail-rods, rolled, basis	£15	15	0	to	£16	0	0
Blooms	£10	0	0	to	£12	0	0
Keg steel	£30	0	0	to	£31	0	0
Faggot steel	£18	0	0	to	£23	0	0
Bars and rods dead soft, st'l	£10	0	0	to	£12	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

		£	s.	d.		
Sept.	13 ..	27	7	6	dec.	1/3
,,	14 ..	27	6	3	,,	1/3
,,	17 ..	27	5	0	,,	1/3
,,	18 ..	27	6	3	inc.	1/3
,,	19 ..	27	10	0	,,	3/9

Electrolytic Copper

		£	s.	d.		
Sept.	13 ..	30	5	0	dec.	5/–
,,	14 ..	30	5	0	No change	
,,	17 ..	30	10	0	inc.	5/–
,,	18 ..	30	5	0	dec.	5/–
,,	19 ..	30	7	6	inc.	2/6

Standard Tin (cash)

		£	s.	d.		
Sept.	13 ..	229	17	6	inc.	20/–
,,	14 ..	229	5	0	dec.	12/6
,,	17 ..	228	10	0	,,	15/–
,,	18 ..	228	15	0	inc.	5/–
,,	19 ..	228	15	0	No change	

Tin (English ingots)

		£	s.	d.		
Sept.	13 ..	230	0	0	inc.	20/–
,,	14 ..	229	0	0	dec.	20/–
,,	17 ..	229	0	0	No change	
,,	18 ..	228	15	0	dec.	5/–
,,	19 ..	228	15	0	No change	

Spelter (ordinary)

		£	s.	d.		
Sept.	13 ..	12	11	3	inc.	3/9
,,	14 ..	12	11	3	No change	
,,	17 ..	12	8	9	dec.	2/6
,,	18 ..	12	5	0	,,	3/9
,,	19 ..	12	7	6	inc.	2/6

Spelter (Electro. 99.9 per cent.)

		£	s.	d.		
Sept.	13 ..	15	2	6	inc.	2/6
,,	14 ..	15	2	6	No change	
,,	17 ..	15	0	0	dec.	2/6
,,	18 ..	14	17	6	,,	2/6
,,	19 ..	15	0	0	inc.	2/6

Zinc Sheets (English)

		£	s.	d.		
Sept.	13 ..	23	5	0	No change	
,,	14 ..	23	10	0	inc.	5/–
,,	17 ..	23	10	0	No change	
,,	18 ..	23	10	0	,,	,,
,,	19 ..	23	10	0	,,	,,

Lead (English)

		£	s.	d.		
Sept.	13 ..	12	10	0	inc.	5/–
,,	14 ..	12	10	0	No change	
,,	17 ..	12	10	0	,,	,,
,,	18 ..	12	10	0	,,	,,
,,	19 ..	12	10	0	,,	,,

Imports and Exports of Pig-Iron, Iron and Steel Castings, etc., in August and the eight months, 1934, compared with a year ago.

	August.		Eight months.		August.		Eight months.	
	1933.	1934.	1933.	1934.	1933.	1934.	1933.	1934.
	Tons.	Tons.	Tons.	Tons.	£	£	£	£
Imports.								
Pig-iron, forge	—	—	—	—	—	—	—	—
,, foundry	5,351	2,447	26,274	21,305	17,668	7,444	91,130	61,406
,, acid	—	—	37	—	—	—	226	—
,, basic	9,000	8,338	37,338	47,332	24,194	23,907	99,992	130,040
Total (including other kinds)	14,351	11,340	63,649	78,232	41,862	34,904	191,348	246,342
Castings and forgings	78	336	715	2,724	2,231	9,000	16,460	69,019
Cast pipes and fittings	78	51	894	764	2,516	2,832	18,049	42,100
Stoves, grates, etc.	26	265	420	770	3,117	14,150	38,801	62,804
Baths	816	806	3,980	5,220	18,816	20,872	92,497	129,202
Hollow-ware, all kinds	281	185	1,563	1,619	9,975	12,375	63,115	92,875
Exports.								
Pig-iron, forge	425	75	1,522	729	1,636	299	5,964	3,024
,, foundry	3,759	7,370	30,893	48,462	14,014	23,691	107,988	163,700
,, acid	4,769	4,206	34,088	29,970	14,508	13,282	105,491	94,819
,, basic	140	24	1,030	832	544	89	4,037	2,725
Total	9,093	11,675	67,533	79,993	30,702	37,361	223,480	264,268
Castings and forgings	247	618	1,786	3,461	9,645	24,800	75,962	131,918
Cast pipes and fittings, up to 6 in. diameter	5,011	4,255	32,489	41,076	54,718	48,378	356,783	452,389
,, ,, ,, over 6 in. ,,	2,222	3,089	19,479	25,333	17,029	19,774	140,351	186,358
Stoves, grates, etc.	572	889	4,169	5,714	29,419	33,931	201,427	266,764
Sanitary cisterns	176	224	1,620	1,965	5,108	6,571	48,085	57,770
Bedsteads, inc. tubes therefor	287	521	2,553	3,515	10,088	16,357	94,326	115,217
Cast hollow-ware	373	275	2,673	2,291	14,046	10,996	107,260	87,686

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